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TEXTILE FIBERS, YARNS, AND FABRICS

The Century Vocational Series
Edited by Charles A. Prosser

TEXTILE FIBERS, YARNS, AND FABRICS

BY

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PREFACE

The study of textiles is becoming more and more a part of the home economics curricula in both high schools and colleges throughout the country. Women interested in club work are making efforts, through legislation, to improve the social and economic conditions of the textile industry and to standardize textile products.

Realizing a need, I have prepared this text to cover in a concise way the whole textile field. The course of study which it offers is practicable for textile classes in high schools or colleges and for study classes in women's clubs. The material presented is the result of years of work in developing a practical course in the teaching of textiles in colleges.

I wish to acknowledge my appreciation of the loan by the Silk Association of America of the photographs of silkworms and cocoons, which were procured through the kindness of Mr. Beveridge C. Dunlop, Vice-President of the American Glanzstoff Corporation of New York City. Acknowledgment is also due to the Viscose Company of New York for permission to use the illustration showing steps in the manufacture of viscose.

HELEN A. BRAY.

INTRODUCTION

This book has been written to give girls and women a better understanding of textiles so that they may become more competent purchasers and users of fabrics. It presents information, suggestions, and directions concerning every kind of textile fiber, yarn, and fabric, which not only every student of home economics, but also the women of every household, should have. It will aid in the education, as a consumer, of the most important buyer in our country—the American homemaker. From this standpoint, such a book has economic and social, as well as educational, value.

Almost all that we produce on farms and in shops finds its way ultimately into the home. The typical American buyer is the woman who is married and the mother of, let us say, two children. She buys and uses for herself and her family at least 96 per cent of everything produced in this country or imported from other lands. Upon the intelligence with which she discharges her responsibility depends not only the welfare of the home but also our commercial well-being. From the social point of view, every dollar which is expended to equip her for the more efficient performance of her task is worth many times as much as the money used in advertising. From the economic standpoint, every producer should be vitally interested in the development of better taste as shown in the appearance of everything used in the home, and in the development of better standards of quality and usefulness. If this be true, then every maker and dealer as well as user of textiles and fabrics in any form will find Miss Bray's book helpful.

No other buyer, not even the purchasing agent for a manufacturing establishment or for a department store, purchases so many different kinds of goods as the American homemaker. With the possible exception of food, her largest outlay of money is for textiles in all their various forms—carpets, rugs, mats, curtains, draperies, linen, and an infinite variety of cotton, wool, and silk fabrics which are bought either ready-made or by the yard. This book is concerned only with her problems in the selection, purchase, and use of textiles.

Like any other buyer, the woman of the household faces certain problems. She is expected to meet certain reasonable standards in the discharge of her responsibility as the purchasing agent for the family. She has only a certain amount of money to use for fabrics and she is expected to get the best possible returns from its expenditure.

To do this, she must know how to detect adulterations and false fillings in goods. She must know what kinds of textiles are durable and what kinds are not, and she must be able to distinguish between the two. She must know the difference between standard fabrics and those which are a temporary fad. She must know what colors and designs are suitable for given conditions. She must know what is appropriate to the circumstances and to the financial status of the family. She must know when it pays to buy articles ready-made and when to have them made. She must know where to buy, when to buy, and how to buy. All these things are the earmarks of an informed homemaker, shrewd and resourceful in the expenditure of the family resources.

To help women to become competent buyers of fabrics, Miss Bray has prepared this book. She has put into it careful study, thorough knowledge of the subject, and experience acquired as a successful teacher of textiles and clothing. Out of all the great body of information regarding textiles which has been

accumulated, she has culled that which the homemaker needs to know. This information she has analyzed and presented in a terse way.

The classification of textiles is sound; the language is clear; the treatment is interesting; and the organization of the material makes this volume a ready handbook in which information can easily be found when needed. One of the most praiseworthy features is the excellence of the many illustrations used and their close adaptation to the text. What the author has done primarily is to interpret for all women the facts about textile fibers, yarns, and fabrics which they must know and apply if they are ever to realize their possibilities as efficient purchasing agents for the home. This is a service which needs to be performed for other subjects by technicians in other fields.

If the foregoing be sound, then this book should prove helpful for all classes preparing young women to serve as teachers of home economics and for all day and evening schools in which girls and women are being trained for the duties of the home. Every housekeeper needs such a book, and every one interested in textiles and fabrics from any angle will find it interesting and profitable.

C. A. Prosser.

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PART I

TEXTILE FIBERS

CHAPTER I

CLASSIFICATION OF THE FIBERS

Four of the greatest needs of the human race are food, shelter, clothing, and fuel. Clothing is probably next to food in importance. Among civilized peoples, clothing is not only an actual physical need, but, because of custom and fashion, it contributes largely to the happiness and social status of the individual. All the clothing which we wear is made from various textile fibers which have been in use by the people of different nations throughout the ages, for the textile art is one of the oldest arts of the human race.

Textile fibers. The textile fibers are the raw materials from which fabrics are manufactured. These fibers are divided into two large groups—the major and the minor fibers. The general source of supply consists of the five major fibers, which are wool, silk, cotton, flax, and the artificial silks or rayons, as they are now called.

Major fibers. The major fibers are those fibers which have the following properties: a physical structure which has enough tensile strength and pliability to make a yarn suitable for weaving; a length of at least five millimeters for spinning; and a cohesive quality, so that they hold together when spun. Most of the fibers have irregularities on the surface, which cause frictional resistance in spinning: for instance, wool has serrated edges; cotton, a natural twist; and flax, knot-like formations or nodes throughout the length of the fiber. The fibers should have elasticity and resiliency, and the staple

should be fine enough to produce a fine yarn, uniform in length and diameter. Another necessary property is that of porosity; that is, the fibers must be capable of absorbing liquids, in order that fabrics may be bleached and dyed. They should be durable, so that they will withstand the wear to which they are to be subjected. They should be available in large enough quantities for commercial use. The supply should be more or less constant and easily marketed.

General classification of fibers. Textile fibers are divided into four classes: (*a*) animal, (*b*) vegetable, (*c*) mineral, and (*d*) artificial.

a. Animal fibers. These are nitrogenous substances (proteins), and the wool and hair fibers contain sulphur. The protein matter is albuminous in character. It is characterized by an empyreumatic odor when burned. The major fibers are wool and silk, and the principal minor fibers are mohair, alpaca, cashmere, camel's hair, and rabbit hair.

b. Vegetable fibers. These consist of plant cells, and are all of cellulose composition, belonging to the carbohydrate group. The cellulose rarely occurs in a free state, but is usually combined with other substances, principally fat, wax, coloring matter, and tannin. Chemically, it consists of carbon, hydrogen, and oxygen. The formula is $C_6H_{10}O_5$. The major vegetable fibers are cotton and flax. The rayons may also be classed as major vegetable fibers as well as artificial fibers. The most important minor vegetable fibers are jute, ramie, piña, kapok, and the different varieties of hemp.

The vegetable fibers may be classified according to the part of the plant from which they are derived. These are (1) the seed hairs which are attached to the seed capsules of certain plants such as cotton and vegetable silks; (2) the bast or stem fibers—flax, hemp, jute, and ramie—which are taken from the stalk of the plant; (3) the leaf fibers, including the

New Zealand and the Manila hemps, which are taken from the leaves of certain plants; and (4) the fruit fibers, only one of which—the cocoanut—is used to any great extent, this being utilized principally for mats and brushes.

c. Mineral fibers. In comparison with the other fibers, the mineral fibers are rarely used in the textile industry. Asbestos is really the only mineral fiber used. There are two varieties: the serpentine, which is composed of the silicate of magnesium and calcium with some iron; and hornblende, similar in composition, but containing aluminium. The fibers of asbestos are very straight and glossy and very difficult to spin. They are often mixed with cotton and linen, though they may be spun alone.

d. Artificial fibers. The artificial fibers are of animal, vegetable, or mineral origin. Those of mineral origin are: spun glass, slag wool, and the metallic threads. Spun glass is made by drawing out molten glass into a fine thread. Because of its lack of elasticity it is not used to any great extent.

Slag wool, also called *mineral wool,* is used chiefly as a packing material. It is made of molten slag which has been subjected to a strong blast of steam or compressed air.

The metallic threads are made by drawing out gold, silver, copper, etc., into threads after heating them until soft. Pure metallic threads, however, are rarely made at the present time. Gold threads are made by covering fine silver wire with a layer of gold, and silver threads by covering fine copper wire with silver. The imitations are made by covering linen threads with a fine film of gold or silver. The metallic threads are used in decorative fabrics.

The rayons are either of vegetable or of animal origin. They are made by preparing a viscous liquid of about the consistency of molasses, composed of either cellulose or gelatine derivatives, and drawing out the liquid through fine jets

and coagulating. The resulting filaments are then ready to spin.

Economic classification of fibers. Fibers may be classified from an economic standpoint as follows: (1) the felting fibers, consisting of wool and the various kinds of hair, for both cloth and hats; (2) spinning fibers, consisting of cotton, flax, jute, hemp, ramie, pineapple, the rayons, wool, silk, mohair, alpaca and others; (3) fibers for cords and ropes, such as the sisal and Manila hemps; (4) fibers for hats: rice, wheat, or barley straw for the Tuscan and Japanese braids, plaits of split leaves for the peanut and Panama hats, and horsehair for the Neapolitan braids; (5) coarse fibers for weaving and plaiting mats and floor-coverings; (6) the stems and split leaves of various plants used for weaving and plaiting baskets; (7) fibers for filling cushions, pillows, and mattresses, consisting of cotton, hair, kapok, straw, and the like.

CHAPTER II

WOOL AND HAIR FIBERS

Structure of the fiber. Wool is a growth originating from a gland found in the middle layer of the skin of the sheep. This gland secretes a lymph-like liquid from which the hair grows, and also an oil, which acts as a lubricator, giving it elasticity and pliability. There are also a number of sebaceous glands in the skin which secrete a fatty substance called wool-fat. This forms a protective coating for the fiber and prevents the fibers from felting and matting together. The wool fiber contains about 40 per cent fats and oils; about 30 per cent is the fiber proper; and the remainder consists of impurities and foreign matter which adheres to the fiber.

Parts of the wool fiber. Wool consists of three distinct parts: (1) The outer layer or epidermis is composed of horn tissue in the form of flattened scales. These scales overlap and project out over the edge of the fiber, giving it a serrated appearance. This structure gives the fiber its resistance to strain and its luster. The smoother the surface, the greater the luster. According to most authorities, the felting or shrinking property is due to the interlocking of the scales. The more serrated the edge of the fiber, the greater its felting property. Other authorities say that if the scales interlock, two fibers would necessarily be brought together from opposite directions; therefore a more recent theory is that the felting property depends on the natural wave of the fiber and the intertwining of the mass of fibers among themselves. (2) The middle

or cortical layer of the fiber is the true fibrous portion, and it forms the essential part of the fiber. It consists principally of elongated cells, which give the fiber its tensile strength and elasticity. (3) The pith of the fiber, called the *medulla,* consists of round or flattened cells, which often contain coloring matter. Sometimes this pigment not only permeates the medulla, but also the cells of the cortical layer, giving the whole fiber a colored appearance. Its chief function is to nourish the fiber, a process accomplished by the flow of the juices through the inner canal of the medulla.

Physical properties of the fiber. The physical properties of the wool fibers vary, depending upon the breed of the sheep and the part of the animal from which the wool is clipped. The tensile strength is the least among all the major fibers.

The length varies from one to eight inches. The average length is four inches. The fibers are divided according to the length of staple into two classes, *tops* and *noils.* The tops are the long fibers, which are combed and spun into worsted yarns; while the noils are the short fibers which are combed out in the combing process and are often used for spinning woolen yarns.

Wool is the most hygroscopic of all fibers. When moist, it holds from 12 to 15 per cent of its weight of water, and it may hold from 30 to 50 per cent. The standard is 16 per cent.

The shrinking or felting property of wool depends upon the scales and the serrations on the edge of the fiber. The more serrated the edges, the better the felting properties. Considered hygienically, it is the most difficult of all fibers to keep clean.

Chemical composition. Wool is classed as a protein known as *keratin.* Raw wool as it comes from the fleece contains a large amount of dirt, grease, and dried-up perspiration, all of which are removed in the scouring process. It also contains

several oils and wax-like compounds. It is composed of about one-half carbon, one-fourth oxygen, some nitrogen, and a small percentage of hydrogen and sulphur.

Sources of wool. There are several sources of the wool fibers used in the manufacture of yarns.

a. Virgin wool. More wool is obtained by shearing live sheep than in any other way. This is called *virgin wool.* Lamb's wool is considered better than that from an older animal because the ends of the fibers are pointed and it is usually softer and finer. Sheep's wool is taken from sheep which are two or more years old, and the ends are blunt and thick from former clippings.

b. Pulled wool. The wool which has been removed from the pelts of slaughtered sheep is called *pulled wool.* It may be removed from the skin in several ways: (1) by hanging in a damp place until a slight fermentation takes place, when the wool can be readily pulled away; (2) by painting the skin with a mixture of sodium sulphide, sulphuric acid, and ground oyster-shells, thus loosening the wool so that it can be easily removed, a method used extensively for wools that are to be made into blankets and felts; (3) by steeping in lime-water until the wool is loosened at the roots, a method which has not proved very satisfactory.

c. Dead wool. Wool that has been taken from sheep that have died is called *dead wool.* This is often blended with virgin wool.

d. Remanufactured wools. Wools which are obtained by tearing up old rags and waste and converting these back into a fibrous mass are known as *remanufactured wools.* They are then recarded and respun, either alone, or blended with fibers of virgin wool or cotton. This product is called *shoddy.* Most of the so-called shoddy-mills are merely sorting-plants where shop clippings, old clothes, mill ends, rags, and waste are classi-

fied. The new rags are first separated from the old; then, as far as possible, those containing cotton or silk are separated from the all-wool. After this they are cleaned in a shaker or washed. If mixed with cotton, they are carbonized to destroy the vegetable matter, neutralized, washed, and dried. The decomposed vegetable matter is removed by dusting and the wool is then torn up into a fibrous mass ready for carding.

Kinds of shoddy. The different kinds of shoddy are as follows: (*a*) softs, (*b*) mungo, (*c*) extract wool, and (*d*) flocks.

a. Softs, the best kind of shoddy, is made from all-wool rags, or waste which has not been fulled. It is usually blended with virgin wool and remanufactured into an average grade of yarn. The fibers average in length about one inch.

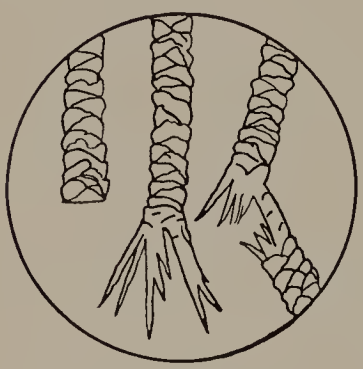


FIG. 1
WOOL FIBERS COMPARED
Left, virgin wool; middle and right, shoddy.

b. Mungo is made from woolen rags which have been felted and napped. When the rags are torn, the fibers are often torn also. These fibers are shorter, and therefore of less value than the softs, and usually produce a fabric of inferior quality.

c. Extract wool is obtained by carbonizing rags of mixed cotton and wool fibers. This process destroys the vegetable matter and leaves the wool. The rags are either steeped in sulphuric acid to remove the cotton, or are treated by the more modern method of carbonizing with hydrochloric acid gas.

d. Flocks. The short, waste-wool fibers, which have been recovered in the finishing process of cloth, are often utilized, as are also the clippings from the napping machines, by being

pressed and felted into a loose fabric. These short fibers are called *flocks*.

There are no reliable chemical tests by which shoddy may be distinguished from the virgin wool. The only means is the use of the microscope. Under the microscope, shoddy may show the presence of other fibers beside wool, and the ends of the fibers often have a torn appearance or are forked or brush-like. The ends of the virgin wool fibers, however, appear to have been cut.

Quality of the wool fiber. The quality of the fiber depends upon the breed of the sheep, the part of the animal from which the wool is clipped, climatic conditions, and the nature of the pasturage. Australia has the best climate for the production of wool. A loamy soil produces the best pasturage. A chalky or alkaline soil often causes the wool to be coarse and brittle. The average amount of wool obtained from each sheep is from four to fifteen pounds, although some South American breeds have produced as much as forty pounds.

Breeds. The breeds of sheep are known as *pure-blood merino* and the *merino strain*. The latter has been developed into new breeds known as *half-blood, three-fourths blood* and *three-eighths blood*.

Countries producing wool. Wool is produced in many foreign countries. The Saxony and Silesian wools are considered the best because of their fine, uniform staple and good felting properties. They are used mostly in the manufacture of woolens. Australia ranks first among the wool-producing countries. The Australian wools are the Port Philip, the Sidney, and the Adelaide. In South America, the chief kinds are the Buenos Ayres and the Montevideo merinos. In Africa, Cape Colony and Natal produce fine merino wools. The British wools are divided into three groups: the Longwools, which include the Leicester and the Lincoln wools; the Shortwools, including

the Southdown, the Shropshire, and the Suffolkdown; and the Mountain wools, which are the Cheviots, the Blackface, the Shetland, and Irish, and the Welsh.

The United States is third in production. The annual production, which is about 275,000 pounds, has decreased about 30 per cent in the last thirty years. Present consumption is about double the annual production. There are two classes of wool in the United States: the Domestic, the best grade being merino, which comes from the Ohio Valley; and the Territory, the latter coming from Nevada, Montana, the Rocky Mountain Plateau, Idaho, and Wyoming. Texas and California are classed separately because they shear twice a year.

Microscopic appearance of the wool fiber. Under the microscope, wool can readily be distinguished by its scales from all other fibers. The scales differ in the different varieties of wool. The scales of the fine merino wools are in the form of cylindrical cusps, one slightly overlapping the other so that a single scale completely surrounds the fiber. In some cases the edges of the scales are smooth and straight. This is characteristic of a fine quality of wool; the coarse varieties have serrated, wavy edges. The length of the projecting scales also affects the quality of the fiber. In some wools, the scales project one-third of the entire length of the scale from the body of the fiber. These wools are best for felted fabrics.

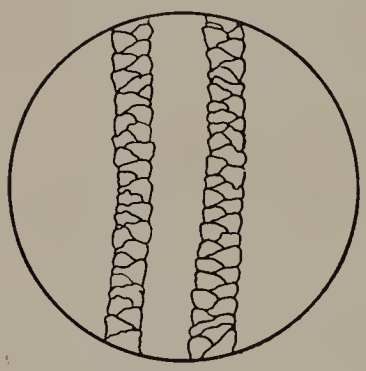


FIG. 2
VIRGIN WOOL FIBERS

Marketing wool. The principal markets for wool are Philadelphia, New York, Boston, Chicago, and St. Louis. There are several ways of selling wool: (1) It may be sold direct

to the mills, as is customary in the Middle West. (2) It may be sold to local dealers, who in turn sell to buyers, usually at a profit. This is done more often by the small grower. (3) Merchants may send a buyer to the wool-producing centers. The buyer pays cash for the wool and sends it to a warehouse. Here it is graded and sold to the mills on credit. (4) The wool-grower may sell to buyers representing the mills, thereby eliminating the middleman's profit. Only a few large mills follow this procedure. (5) Large wool-growers often send the wool direct to the commission houses or merchants. The wool is graded by experts. In this case the grower pays the transportation charges and a commission. (6) The wool is sometimes sold through farmers' coöperative sales agencies. This practice, however, has not been very satisfactory. (7) Foreign sales are conducted mostly by auction.

Grading wools: The best grade of wool sets the standard for grading. There are two methods in use: the bloods and the counts. The bloods were originally determined by the breed of the sheep, but are now determined by the degree of fineness of the fiber. They are (1) United States Domestic and Foreign bloods: full-bloods, three-quarter bloods, one-half bloods; (2) United States Territory: fine staple, fine medium staple, and fine medium clothing; (3) pulled wool: AA, A, B, and C. The counts are determined by the number of hanks of 560 yards to a pound. The Foreign and the United States differ somewhat in counts.

Minor hair fibers. Those fibers which do not possess the properties necessary to produce satisfactory textile fabrics, or which are not produced in large enough quantities, are considered the minor fibers.

Large quantities of hair are used in the textile industries. They are used more or less with wool and go through similar processes of manufacture. The principal hair fibers are: (*a*)

mohair, (*b*) alpaca, (*c*) cashmere, (*d*) camel's hair, and (*e*) rabbit hair.

a. Mohair. The fiber obtained from the Angora goat is known in the trade as *mohair.* The fiber is very fine in staple. It has a high luster and is slightly wavy, but has no curl.

FIG. 3

ANGORA GOATS IN SHEARING PEN

This photograph was made on a ranch in West Texas.

Mohair was grown originally in Turkey. At the present time it is grown quite extensively in the United States, principally in Oregon, California, and Texas. Texas produces the finest grade of domestic fiber, although the fiber is shorter, because the goats are sheared twice a year. The quality, however, depends upon the luster rather than the length of staple.

Mohair is used extensively in the manufacture of plushes, braids, dress materials, linings, and felt hats. It is rarely used

alone. Usually it is combined with wool, cotton, or silk. The coarser grades are used for carpets, cheap woolen fabrics, and blankets.

Under the microscope the epidermal scales are not so distinct as those of wool. They are thin, flat, irregular in outline, and broader than the wool scales. A single scale often surrounds the entire fiber. The scales are smooth, without serrations, and do not project over one another. The striations of the cortical layer may be seen through the transparent scales.

FIG. 4
MOHAIR FIBERS

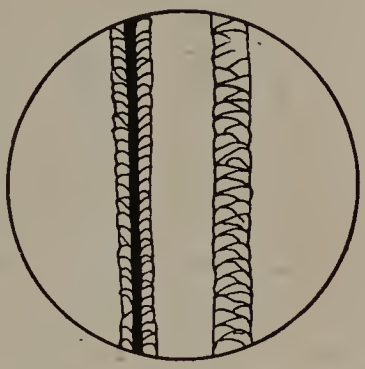


FIG. 5
ALPACA FIBERS

Left, beard-hair; right, wool-hair.

b. Alpaca. The alpaca fiber is obtained from a sheep-like ruminant animal of South America. In color it may be white, black, or various shades of brown. The reddish-brown variety is considered the most valuable. There are two kinds of fibers: the soft wool-hair, which is very smooth, and has indistinct scales when seen under the microscope; and the stiff beard-hair, which has a broad medulla showing through the center of the fiber.

c. Cashmere. The hair from the cashmere goat comes from the mountains of India and China. These goats are not sheared

like the other hair-producing animals, but are combed when the animals shed their hair. The fiber is very soft, and for this reason it is used extensively in the production of fabrics having a soft nap. The famous India shawls are made from the hair of the cashmere goat. The fiber is from one and one-fourth to three inches in length and is white or gray in color. There are two varieties of the fiber: the soft wool-hairs having visible scales with finely serrated edges; and the coarse beard-hairs showing a well-developed medulla.

d. Camel's hair. Most of the camel's hair comes from China and Russia. The fiber is very soft and strong. It is used in the natural color, which is tan, or dyed with dark colors. It does not bleach readily. Like the cashmere, there are the two growths: the soft wool-hairs, and the much stiffer beard-hairs Both show faint scale markings and longitudinal striations.

e. Rabbit hair. Rabbit hair is usually light brown in color. It has good felting properties and is therefore used extensively in the manufacture of felt hats. With the microscope it may be seen that each scale is placed into the one below. The epidermal scales are quite thick, and spiral striations are visible.

CHAPTER III

SILK

The silk fiber is a liquid called *fibroin,* excreted from the glands of the silkworm into a continuous thread, which hardens as it comes in contact with the air.

Courtesy of the Silk Association of America.

FIG. 6
SILKWORMS

The worm. The insect which makes the silk fiber is the larva of a small moth, called the *Bombyx mori,* or *mulberry silk-*

worm. The full-grown worm is about three inches in length. Its framework consists of twelve concentric rings of cartilage, connected by a soft elastic skin. Its head is very small, and there are two jaws which grind and masticate the food. Respiration is carried on through tiny openings which appear as black spots on the concentric rings and connect with the venous system.

Courtesy of the Silk Association of America.

FIG. 7
FEEDING SILKWORMS

The fibroin. Luther Hooper, in his book *Silk,* shows a longitudinal section drawing of a full-grown silkworm and the glands in which the fibroin is made and stored. The drawing shows three principal parts: the main artery connecting with the respiratory ducts; the alimentary canal, which all the food enters after being masticated; and the reservoirs and their organs. The reservoirs and glands are on either side of the alimentary canal. Just below the posterior spine are tiny twisted

glands in which the fluid fibroin is formed. The glands connect with reservoirs, where the fluid is stored. It then passes on to the discharging tubes, which end in a double orifice just below the mouth, from which the fiber of fibroin is discharged. The fibers vary in length from 400 to 1,300 yards. From 8 to 10 per cent of the silk fiber in the cocoon is available for reeling. The remainder is waste and broken threads, which are used in the manufacture of spun silk.

Courtesy of the Silk Association of America.

FIG. 8

SILKWORMS IN BASKET

Sericin. The worm also excretes another glue-like substance which holds the two fibers of fibroin together. This is a transparent fluid either white or yellow in color, and seems to penetrate the fibers, as the cocoons from the cultivated silkworm are either white or yellow in color. The coloring matter, however, is removed in the degumming process, leaving the silk almost white. Some authorities say that the sericin is not

secreted in the glands with the fibroin, but is an excess of water and oxygen added to the fibroin and converted into sericin as it passes through the discharging glands.

Courtesy of the Silk Association of America.

FIG. 9

THE SILKWORM IN ITS THIRD AND FOURTH AGES

Life-cycle of the worm. The silk moth exists in four stages: the egg, the larva, the chrysalis, and the moth. The eggs laid by the moth are very small. They are almost round and resemble turnip-seeds. At first they are yellow in color, but they change to a dark gray. The eggs are laid on white paper or muslin. They are hung away in a damp place for a few days, then placed in cold storage for about six months. When the worm hatches, it is very small and black, and is covered with hair.

There are four molting seasons when the worm sheds the old skin for the new: (1) From birth to the first molt, ranging from five to six days. During this time the worm feeds

Courtesy of the Silk Association of America.

FIG. 10
BREEDING COCOONS

on the mulberry leaves, first sucking the sap, and later gnawing the edges of the leaves. The worm eats about thirty meals a day. (2) First to second molt, covering four days. The worm is now lighter in color, and it develops rapidly, showing the spinning organs. (3) Second to third molt, four to five days. (4) Third to fourth molt, seven to twelve days.

The full-grown worm is now about three inches in length and is white and velvety. The worm eats much less, and shrinks to about an inch in length. The spinning-glands are full of a transparent liquid. The worm indicates a desire to spin by lifting the forepart of the body; twigs are then provided, and the worm climbs onto them. The worm works incessantly, mak-

Courtesy of the Silk Association of America.

FIG. 11
COCOON NESTS

ing sixty-nine movements with its head every minute, describing arcs of circles in the form of a figure eight. It forces the fiber out by the contraction of its body, until it has completely surrounded itself with layer upon layer of a thin, gauze-like network.

The cocoon is completed in about twenty-four hours, and the worm is about one and one-fourth inches in length. Two

days after the cocoon is completed, the skin breaks at the nose and is crowded off the body, leaving the chrysalis, oval in shape and about one inch in length. At first the chrysalis is yellow in color and soft to the touch, but later it turns brown and hardens. After two or three weeks, the shell of the chrysalis breaks, and the moth, which is white in color, is ready to escape. If

Courtesy of the Silk Association of America.

FIG. 12

COUPLES OF MOTHS PLACED IN BASKETS

the moth is allowed to come out, the fibers are so broken that they are ruined for reeling.

Cocoons which are to be reeled are placed in a steam heater to kill the moth; then the fibers are reeled. Usually enough moths for breeding purposes are allowed to escape.

Physical properties. Silk is the longest of all fibers, being from 400 to 1,300 yards in length.

Its relative tensile strength in comparison with its size is greater than that of any other fiber.

The fiber loses some of its elasticity after the gum has been removed in the boiling-off process.

Silk is very hygroscopic. When dry, it will absorb about 10 per cent of its weight in moisture, and when moist, it will absorb about 3 per cent more. It may absorb as much as 30 per cent. The standard is 11 per cent.

In luster, it is next to the rayons, which have the highest luster of all fibers.

Silk is not a good conductor of heat.

It is a good generator of electricity, but a poor conductor.

It is very hygienic, as it sheds dirt readily, and germ life does not increase as rapidly on the silk fibers as on wool.

Courtesy of the Silk Association of America.

FIG. 13

MOTHS EMERGING FROM THE COCOONS IN THE EARLY MORNING HOURS

Silk has a property which is peculiar to itself, that is, the rustle or scroop, which is natural in some silks.

Countries producing silk. Silk is produced in the following countries, in the order of production: Japan, China, the vicinity of Piedmont in Italy, Asia Minor, and France. The United States does not produce raw silk, but imports the greater part of the world's production for the manufacture of silk fabrics.

Chemical composition. In composition, silk is chiefly protein. Unlike wool, it does not contain sulphur. About 63.10 per cent of the fiber is fibroin, 22.58 per cent sericin, and 12.50 per cent water. The remainder is fat, resins, and mineral matter.

Microscopic appearance of the fiber. A fiber from the silk cocoon, or raw silk, shows under the microscope two fibers of fibroin held together with the sericin, which resembles a

canal through the center of the fiber. Leaf-like projections frequently appear. The fiber from which the gum has been removed is smooth, cylindrical, and transparent, with occasional leaf-like projections. Unlike the other major fibers, silk is not cellular in structure.

Wild or tussah silk. There are a number of species of silk-producing moths. A large proportion of them, however, have no commercial value. They feed on oak leaves. Scientists agree that the color of the wild silk fiber is due to this food. The moth is much larger than the cultivated moth. As wild silk does not reel as readily as the mulberry silk, it is necessary, before reeling it, to boil the cocoons in an alkali solution, and then in water to which a small amount of glycerol has been added. This keeps the cocoon moist while it is being reeled. The eggs are hung on the branches of trees, and the worms, when hatched, are allowed to roam among the leaves and feed at will.

FIG. 14

SILK AND WILD SILK FIBERS

Left, raw silk fiber from cocoon; middle, degummed silk fiber; right, wild silk fiber.

Kinds of wild silk. The varieties of wild silk are divided into two groups: (1) Those varieties which have not been punctured and which can be reeled. These are the *Antheræa yama-mai,* which is found in Japan and is a bright green in color; and the tussah silkworm, which is found in China, and of which there are several varieties. These worms produce two crops of cocoons each year: one in the spring, and the other in the autumn. (2) The other varieties are the fibers from the cocoons which are found after they have been punctured by the moth and cannot be reeled. They are used for spun silk. There are two principal species: the *Altacus atlas,* found

in India and produced in large quantities; and another, which is found in Africa, and belongs to the *Anaphe* species. The caterpillars of the latter variety build large nests, and each worm spins its own cocoon inside of the nest. After the moth escapes, the empty nests are collected, cleaned, pulled apart, and sent to the mills.

Properties of wild silk. The color varies from a light écru to a light brown. It has a harsh feel and is wiry. The luster is not so high as that of mulberry silk. It has a good tensile strength. Wild silk does not absorb moisture so readily as the cultivated silk and therefore does not bleach or dye as readily.

Microscopic appearance of the fiber. Under the microscope the fiber appears flat, ribbon-like, and with fine longitudinal striations and leaf-like projections. Occasionally a faint diagonal line may be seen across the fiber.

CHAPTER IV

COTTON AND THE MINOR SEED-HAIRS

The cotton-plant belongs to the *Malvaceæ* or the mallow family and botanically is known as *Gossypium.*

Kinds. Cotton is divided into two main groups: the Asiatic and the Non-Asiatic. The former includes the *Gossypium herbaceum,* which is grown in India, Russia, Turkestan, and Persia, and the *Gossypium arboreum* or tree cotton. To the latter belong the *Gossypium hirsutum* or Upland and the *Gossypium barbadense.* The American Upland belongs to the Upland group, which produces about 60 per cent of the world's supply. The Sea Island cotton belongs to the *barbadense* group.

In the United States, cotton is grown chiefly in Texas, Alabama, Mississippi, Louisiana, Georgia, Florida, and the Carolinas. About one half of the world's production is grown in the United States.

Source. The cotton-plant is a shrub, growing from three to six feet in height, and having spreading branches. The fiber, which is attached to the seed in the boll, is a seed-hair. The bolls vary in size from three fourths of an inch to one and one-half inches in diameter. The Sea Island and Egyptian bolls are elliptical and pointed, while the Upland is shorter and more rounded. The boll is divided into from three to five compartments, each containing a lock of from seven to nine seeds.

The fiber consists of a long, tubular cell with the free end pointed. When growing, the fiber is cylindrical, having a canal throughout its length. When the pod bursts, the cells

collapse and the fiber becomes flat, with the edges or cell-walls somewhat thickened. As the fiber ripens, the juices are drawn back into the plant. This process causes the cell-walls to contract and the fibers to become twisted. The immature fibers are straight and therefore do not spin as well or take dyes as readily as the mature fibers do.

Quality. The quality of the fiber depends upon the seed, the species, the manner of cultivation, the soil, and the climatic conditions. The Sea Island, which is grown on the islands off Charleston, South Carolina, in the West Indies, in Georgia, and in Florida, has the longest staple and the highest luster. The cottons of India have a very short staple and are inferior in quality.

Physical properties. The physical properties of the fiber are as follows:

Cotton has a fair tensile strength, which varies with the different varieties. It is stronger than wool.

It is a better conductor of heat than either silk or wool.

It is less hygroscopic than wool or silk, as it absorbs moisture slowly, but does not give it up readily.

Cotton soils easily because of the fine hairs which protrude from the surface. It is more hygienic, however, than wool.

The fiber is not as elastic as either wool or silk.

Chemical composition. Chemically, cotton is essentially cellulose. Bleached cotton is practically pure cellulose. Raw cotton contains about 5 per cent of impurities, consisting principally of cotton-seed oil, pectic acid, coloring matter, albumen, and wax. The wax acts as a protective coating to the fiber, making it water-repellent.

Economic classification. From an economic standpoint. cotton fibers may be classified as follows:

a. Sea Island has a longer and finer staple than the other varieties. It is about two inches in length. It is very strong and

has more twist, more uniformity in diameter, and greater softness and luster than other cottons. It is used for very fine yarns, laces, thread, and yarns which are to be mercerized.

b. Brown Egyptian has a staple of about one and one-half inches, and *Peeler* a staple one and one-third inches in length. They are both used for very fine fabrics.

c. Orleans and *Allenseed,* which are next in length, are used for ginghams, percales, and madras.

d. Upland, Texas, and *Bowed*s have staples of about one inch in length, and are used for calicoes, sheetings, and the like.

e. Mobile has the shortest staple, being only seven-eighths of an inch long, and is used for very coarse materials, such as ducks, tickings, and the like.

Grading cotton. The grades of cotton have been fixed by the United States government as follows: (1) White cotton: middling fair, strict good middling, good middling, strict middling, middling, strict low middling, low middling, strict good ordinary, good ordinary. (2) Yellow tinged: strict good middling, good middling, strict middling, strict low, strict low middling, low middling. (3) Yellow or blue stains: good middling, strict middling, middling.

All grades above middling are known as *higher grades;* those below, as *lower grades.* All grades known as *strict* are half-grades; the others, full grades.

Marketing. Cotton is sold through exchanges, which are located in almost all of the large Southern cities. These exchanges were established to facilitate the buying and selling of cotton. Rules for conducting the sales and the grading of cotton are made by the association of dealers. There are two kinds of sales: spot sales and future sales. In the spot sales, the cotton is delivered at once, and in the future sales it is delivered at some future time. The latter method is more of a speculation than the former.

Markets. The principal markets are New York, which is the largest in the world, and which deals principally in futures; and New Orleans, which deals principally in spot sales. The foreign markets are Liverpool, the second largest in the world, which deals in both spot and future sales; and Bremen, Havre, Alexandria, and Bombay.

Microscopic appearance. Microscopically, the cotton fibers are divided into four classes: (1) Immature and overripe fibers, which appear flat and smooth, showing no suggestion of the inner structure. (2) The fibers which appear mature in some parts and immature in others. (3) The normal or mature fiber, which is ribbon-like and twisted and has heavy cell-walls. (4) Mercerized cotton, which has been chemically treated, the treatment changing the structure of the fiber. Under the microscope, the fiber appears smooth and cylindrical, and shows a slight suggestion of the twist, because usually all of the twist is not removed in the mercerizing process.

FIG. 15
COTTON AND MERCERIZED COTTON FIBERS
Left, mature cotton fiber; middle, immature cotton fiber; right, mercerized cotton.

Minor seed-hairs. Under the minor seed-hair classification are included: (*a*) bombax cotton, and (*b*) kapok.

a. Bombax cotton. There are several varieties, all of which are very similar in appearance and practically the same in properties. The fiber is called *vegetable down* or *bombax cotton.* It is derived from a plant called the *cotton-tree*, which belongs to the *Bombaceæ* family. It is found only in tropical countries. The fiber is very short and much weaker than that of ordinary cotton. It is very soft and lustrous. It is never used alone,

but is sometimes spun with cotton; it is used principally for wadding.

b. Kapok. This is a seed-hair which is obtained from the *Bombax pentandrum.* It is similar to the bombax cotton in its physical properties and appearance. It is grown chiefly in the Dutch East Indies, where the fruit is picked from the tree, the seed-capsules are broken open, and the fiber is separated from the seed by hand. The fiber is used extensively for mattress fillings, for which it is especially suitable on account of its lightness and its hygienic properties. It is practically vermin-proof, and does not retain moisture. It is used to a large extent in the manufacture of life-belts.

CHAPTER V

FLAX AND THE MINOR VEGETABLE FIBERS

Flax was probably one of the first vegetable fibers, if not the first, used for making cloth. Linen fabrics which have been found on the Egyptian mummies are probably over 4,000 years old.

Structure of the fiber. Flax is a bast or stem fiber, known botanically as *Linum usitatissimum*. It consists of a number of fine threads from twelve to thirty-six inches in length, which extend through the center of the stalk of the plant. In order to obtain the pure fiber, the fiber which is attached to the woody tissue must be separated from this portion of the stem. This is accomplished by retting, a process of fermentation rendering the intercellular matter, which is principally calcium pectate, soluble, and thereby causing the fiber to be readily removed from the stalk.

The plant. The flax-plant is a slender stem from twenty to forty inches high and branching at the top. The flowers are blue, and the round, five-lobed seed-pods are about the size of a pea. When ripe, the seed-pods are straw-colored. The color of the fiber varies, depending chiefly upon the retting process. The best varieties are water-retted and are yellowish white in color. Fibers which have been dew-retted are gray in color. Two bushels of flaxseed are sown to the acre and the yield is from 600 to 800 pounds.

Countries producing flax. Russia produces the largest amount of flax, about four-fifths of the world's supply. Poland

and Belgium are next in order of production. Other countries producing flax for the fiber are France, Ireland, and the Netherlands. Up to the present time the United States and Canada have grown flax principally for the seed. Recently, however, mills manufacturing cloth from locally grown and prepared flax fibers have been established in the Willamette Valley, Oregon. This has given an impetus to the flax-growing industry in the state, which has been aided considerably through funds appropriated by the Oregon state legislature. Flax-pulling machines were introduced in 1923 and are used in pulling the plants. Formerly the pulling was done entirely by hand, both in this country and abroad. If this invention is successful, it may mean as much to the flax industry in the United States as the invention of the cotton-gin meant to the cotton industry.

Physical properties. Flax is the strongest of all vegetable fibers. Over-retted flax, however, is brittle and weak.

The average amount of moisture in flax is from 6 to 8 per cent, though it may contain as much as 20 per cent. Water evaporates quickly from linen; therefore it is especially practical for towels, handkerchiefs, and the like.

Flax takes dyes less readily than cotton and does not bleach as well.

It is a better conductor of heat than cotton.

It is the cleanest of all fibers, and germ life does not increase on it as rapidly as on the other fibers.

Because of its luster and cool, leathery feel, it is especially appropriate for table linen.

Microscopic appearance of the fiber. The fiber is a somewhat irregular cylindrical tube composed of many cells having solid cell-walls. A canal or lumen extends throughout the length of the fiber and shows as a dark line. Nodes or knot-like formations and cracks in the fiber appear frequently.

Chemical composition. Flax is essentially cellulose. Over 80 per cent of the fiber is cellulose and about 3 per cent is intercellular matter. The remainder is composed chiefly of fat, wax, and water.

Minor vegetable fibers. The minor vegetable fibers include: (*a*) jute, (*b*) ramie or China grass, (*c*) hemp, (*d*) Manila hemp, and (*e*) piña, or pineapple fiber.

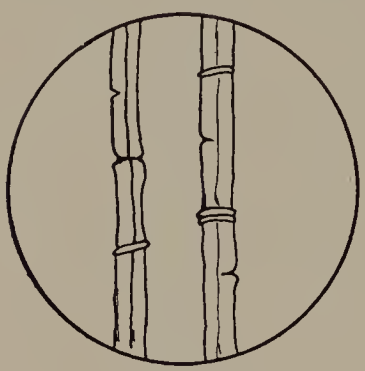


FIG. 16
FLAX FIBERS

FIG. 17
JUTE, SISAL, AND MANILA HEMP FIBERS
Left, manila hemp (*abaca*); middle, sisal hemp; right, jute.

a. Jute. Jute is a bast fiber, grown in India on the plains of Bengal, and in the East Indies. The plant is called Jew's mallow. Its botanical name is *Corchorus capsularis.* The seed is sown in February or March. The plant grows from five to ten feet high and the average yield per acre is about 1,200 pounds. The plant is cut while in bloom, dried, and retted in stagnant water. The fiber is from four to seven feet in length and is either white or gray in color. Jute is the cheapest of all textile fibers and produces the cheapest fabric. The principal markets for the trade are Calcutta, London, and Dundee. Chemically, the fiber is not pure cellulose, but contains some

woody matter known as lignocellulose. The fibers are much weaker than flax; when exposed to moisture, they lose their strength and are brittle. The fiber has a high luster. It takes dyes readily, but does not hold them. The fiber is used principally in the manufacture of burlap, twines, carpet yarns, linoleum, and cheap tapestries. Under the microscope, the jute fiber is smooth and lustrous; the lumen is somewhat irregular.

b. Ramie. Rhea, China grass, or ramie is a bast fiber belonging to a species of stingless nettle known as *Bœhmeria.* It is found in India, China, Japan, Southern Europe, and the southern part of the United States. There are two species: the ramie or rhea, which botanically is *Bœhmeria tenacissima;* and the China grass, the *Bœhmeria nivea.* The fiber from the former is the stronger.

FIG. 18
RAMIE FIBERS

The plants grow from five to eight feet high and are cut when mature. The woody matter is stripped and scraped, while green, by hand. When dry, it is either dew-retted or water-retted and the gum is removed by chemicals. The gum consists principally of cutose, vasculose, and pectose. The two former can be dissolved with soap and caustic alkalies under pressure, after which the pectose can be removed by washing. If all of the gum is not removed, the fiber is very stiff. Because of the difficulty of decorticating, the fiber has not been very profitable from a commercial standpoint, although it possesses all the properties which are most desirable for textile fabrics. There are a few mills manufacturing cloth from rhea in England, France, and the United States.

Ramie is one of the strongest, if not the strongest, of the

textile fibers. It is not easily affected by moisture, but does not take dyes readily. Apparently it does not contain coloring matter. It can be separated into fibers almost as fine as silk, and the luster is almost equal to that of silk. It can be recognized under the microscope by its very large bast cells and its large joints.

c. Hemp. There are over thirty varieties of hemp, all similar in appearance and properties. Hemp is the bast fiber of the *Cannabis sativa,* a shrub grown originally in India, but now cultivated all over the world. The fiber is from forty to eighty inches long and the color varies from yellow to brown or light gray. It has a high luster, fine staple, and high tensile strength. Under the microscope the fiber is often difficult to distinguish from flax. The ends of the fibers, unlike those of flax, are often forked, and the interior canal is hard to distinguish.

d. Manila hemp. While most of the other varieties of hemp are bast fibers, the Manila hemp, grown in the Philippine Islands, is taken from the leaf stalks of the *Musa textilis.* Both the fiber and the plant are called *abaca* by the natives. The plant is cut and the leaves are stripped off and cut into narrow strips one or two inches wide. The strips are then scraped until the fibers are exposed. The fibers are dried and tied into bundles. The best grades are lustrous and straw-colored, and are very strong and fine. The fiber is used for coarse weaving and cordage. Under the microscope it has the appearance of a bundle of fibers, frequently showing peculiar rectangular markings. The fiber is uniform in diameter, and a distinct lumen is visible.

e. Pineapple fiber. The fiber called *piña* is obtained from the leaf of the pineapple plant. Botanically it is known as *Ananas sativa.* It is white in color, soft, flexible, fine in staple, lustrous, and durable. It is used in the Philippine Islands, prin-

cipally in the manufacture of the piña cloth, a material worn extensively by the natives. Under the microscope, it is easily distinguished from the other fibers by the fineness of its fiber elements, which show as fine longitudinal striations.

CHAPTER VI

RAYONS

Artificial silks or rayons are not substitutes for silk, nor will they replace any of the major fibers. In all probability, increasing use will be made of rayon in materials in which it is combined with other fibers.

Growth of the industry. The growth of the industry in the United States has been remarkable. In 1913 the output was 1,500,000 pounds, while in 1928 it was 97,701,250 pounds, and the industry is still in its infancy.

There have been tremendous strides in the manufacture of materials from rayon in combination with cotton. These materials have a cotton warp and a rayon filling and are very beautiful in color and weave. The most noticeable improvements in the rayons are a finer, more pliable, and softer yarn, a greater resistance to the action of water, and a luster not so metallic. They are now no more inflammable than cotton.

Crêpe effects cannot be produced by the same method as that used on true silks, but are produced by treating the yarns in a solution of caustic soda, which reduces the luster and crinkles the yarn.

The fiber. Rayons are cellulose products, belonging to the carbohydrate group. They are produced by a chemical process of making a viscous liquid, about the consistency of molasses, and converting it into a fiber.

Kinds of rayons. There are several different kinds of rayons on the market, all of which are produced by forcing the liquid

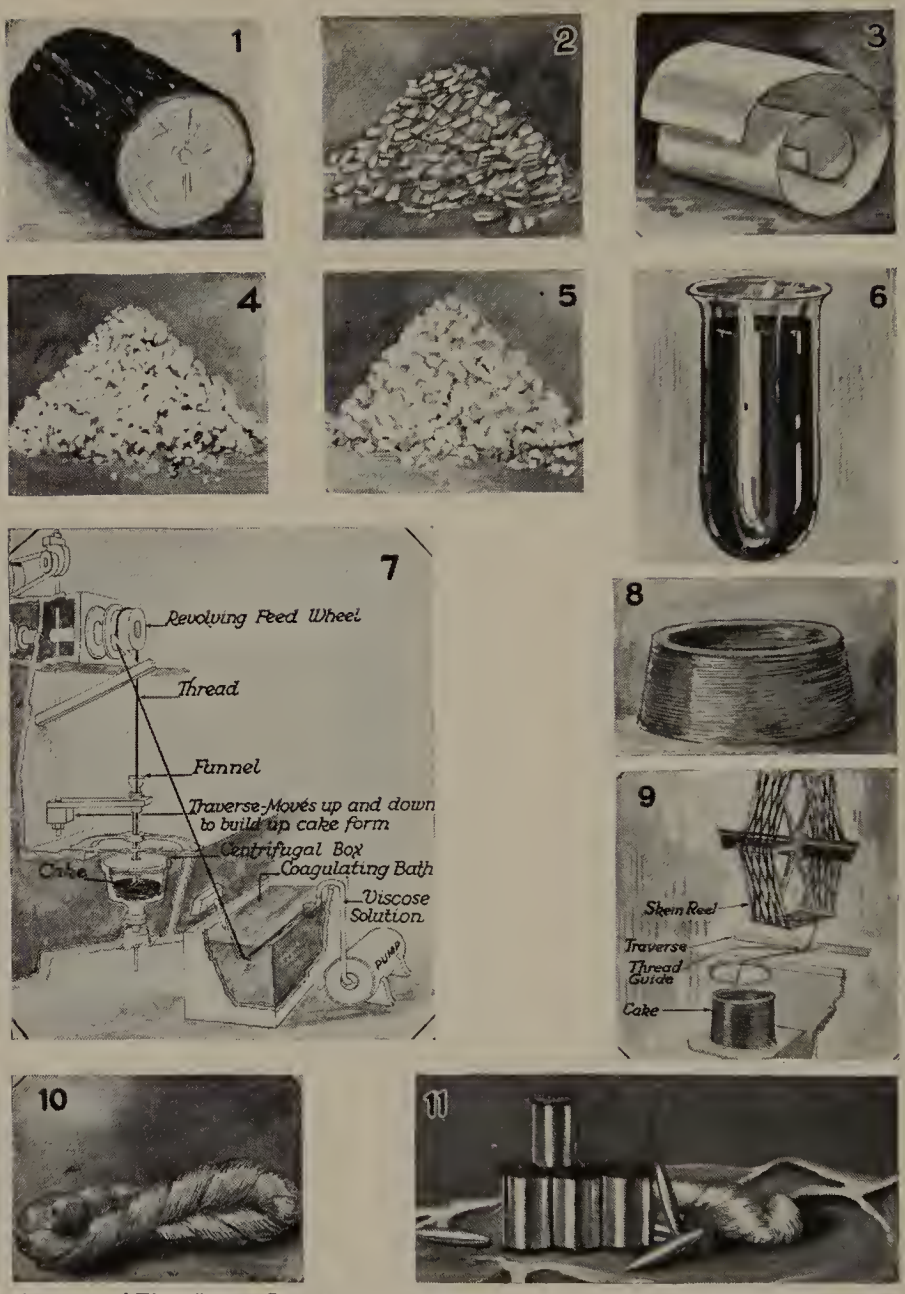
through jets of gold, platinum, or glass. These jets are about one-half inch in diameter, and are perforated with tiny openings, called spinnerets, which vary in diameter from .003 to .004 of an inch.

a. Chardonnet or nitrocellulose. The first artificial silk was patented by Count de Chardonnet in Besançon, France, in 1885. The first silk produced had nitrocellulose as a base and was highly inflammable. Later, de Chardonnet perfected this method by a denitrating process. Artificial silk is now produced by treating purified cotton linters with sulphuric and nitric acids, forming nitrocellulose. This is dissolved in alcohol and ether, filtered, drawn out through spinnerets, and hardened. The nitro groups are removed in an alkaline sulphide bath. The threads are then bleached and wound on bobbins.

b. Cuprammonium. This was first made in Germany by the Glanzstoff Silk Company. The spinning solution is made by treating the purified cotton in an ammoniacal copper oxide solution. It is then drawn out and coagulated in a bath of either caustic soda or sulphuric acid, where the copper and ammonia are recovered. The filament is then bleached and wound on bobbins.

c. Viscose. Viscose was first manufactured in England by Bevan, Cross, and Beedle. Unlike the other rayons, it has wood-pulp as its base. The wood-pulp is brought to the factories in the form of bleached sulphide sheets, which are soaked in caustic soda, forming an alkali cellulose. They are then treated with carbon bisulphide, which forms cellulose xanthate. This is then dissolved in caustic soda, filtered and drawn out, coagulated in a bath of either ammonia sulphate or dilute sulphuric acid, washed in water, neutralized in a solution of sodium sulphide, bleached, and wound on bobbins.

d. Acetate silks. Unlike the other rayons, acetate silk is not regenerated cellusose, but a cellulose ester. It has as its base



Courtesy of The Viscose Company, New York.

FIG. 19

STEPS IN THE MANUFACTURE OF VISCOSE RAYON

1. Spruce wood. 2. Spruce wood chips. 3. Wood-pulp. 4. Wood-pulp treated with caustic soda, giving alkali cellulose. 5. Alkali cellulose transformed into cellulose xanthate. 6. Viscose solution. 7. Spinning. Viscose is forced through holes into a coagulating bath, where the fluid changes into a solid thread, which passes over a wheel into a rotating container. 8. Cake from spinning machine. 9. Reeling into skeins from cake. 10. Unfinished yarn. 11. Finished yarn.

purified cotton or wood-pulp. The cellulose is changed by the action of acetic acid into acetyl cellulose, and dissolved in acetone. It is then filtered, drawn out, hardened by a current of warm air, and wound on bobbins. There are two kinds of acetate silks, lustron and celanese. They are so much alike in appearance and properties that they can be distinguished only by the microscope.

e. Vandura or gelatine silk. Another artificial silk is vandura or gelatine silk. It differs chemically from the others, as it has

FIG. 20

THE RAYON FIBERS

Left, viscose; middle, cuprate or glanzstoff; right, nitrocellulose or chardonnet.

FIG. 21

THE ACETATE SILKS

Left, lustron; right, celanese.

gelatine for a base, and is therefore classified as an animal fiber. It is prepared by forcing an aqueous solution of gelatine through fine jets. The fiber is carried on an endless band through a drying chamber, reeled, and treated with vapors of formaldehyde, making it insoluble in water. The fiber has not been very successful from a commercial standpoint, compared with the other rayons.

Physical properties. The tensile strength of all the rayons is much greater when they are dry than when wet. It varies with the different kinds. The tensile strength of nitrocellulose

and viscose is less than one-half that of true silk, and decreases about 60 per cent when the fiber is wet. The tensile strength of cuprammonium is about one-third that of true silk, and decreases about 75 per cent when the fiber is wet. The acetate silks have a tensile strength of about one-third that of true silk, which decreases about 40 per cent when they are wet, a much smaller loss than that of the other rayons.

All of the rayons absorb moisture readily, and are sold on a moisture content of 11 per cent, the same as true silk.

Microscopic appearance of the fiber. Under the microscope, the different rayons appear as follows: Chardonnet is broad and ribbon-like, having deep lines or folds; cuprammonium is cylindrical, with fine grooves; viscose is flat and ribbon-like, with heavy longitudinal striations.

The two acetate silks differ. Celanese is cylindrical, having a single groove through the center of the fiber, or at one side, while lustron appears as a straight, cylindrical rod. All of the rayons often have little specks or granules showing in groups at intervals, and they are very lustrous.

CHAPTER VII

RECENT DEVELOPMENTS IN TRADE

Recently many developments have taken place in the textile field which tend either to increase or to decrease output, and which have a direct bearing upon the manufactured product. This is equally true with regard to each of the major fibers: wool, silk, cotton, flax, and the rayons.

Wool. The production of raw wool is decreasing in some countries, particularly in the United States. This is attributed to (1) the breaking-up of the large ranches into small farms; (2) the difficulty of securing labor, and its high cost; and (3) the lack of irrigation facilities in the dry sections of the country. Fortunately, owners of sheep are more careful in breeding than formerly. As a result, the fleece is heavier, somewhat compensating for the decrease in the total number of animals sheared. Through the United States Department of Agriculture, an effort is being made to interest farmers in raising small flocks of sheep. In order to revive the industry, breeding centers have been established and better methods of marketing the raw wool are being developed.

Countries producing wool. Australia ranks first in order of production; Europe, second; South America, third; and the United States, fourth. The leading manufacturing countries are: the United States, Great Britain, France, and Germany. In the United States, the largest manufacturing centers are in and around Philadelphia, Pennsylvania; Lawrence, Massachusetts; and Providence, Rhode Island. In this country, woolen

and worsted cloth, carpets, rugs, blankets, and knit goods are the chief products. Great Britain excels in the manufacture of cheviots, serges, tweeds, and other hard-twisted worsteds. On the European continent the softer worsteds and woolens are specialties.

Decrease in the manufacture of wool. There has been a decided decrease in the manufacture of wool materials, particularly for women's wear. In our colder climates, well-heated houses have made the heavy wool materials formerly worn too heavy for comfort. For this reason women have been substituting silk dresses for wool. The woolen and worsted manufacturers have, as a result, become alarmed. In order to meet the situation, they have recently begun to manufacture new wool fabrics entirely different in texture from the customary heavy ones. These new fabrics are very thin, soft, and fine. They include a few transparent materials such as wool georgette, transparent tweed, and silk-and-wool kasha.

Silk. During the last fifty years, the silk industry in the United States has grown by leaps and bounds. The consumption of silk is larger than it has ever been before. In the amount of raw silk imported, this country leads all competitors, as well as in the amount of silk materials manufactured. Of all the silk bought in our department stores, about 90 per cent is "made in America." France is second, but still leads in the beauty of her designs. In this respect, however, the United States is improving.

Decrease in the supply of raw silk. The supply of raw silk is not increasing as rapidly as the demand. For this condition there are several causes. The European countries are not producing as much as formerly, principally because of the scarcity of labor and its rising cost. Consequently, we must continue to rely on our supply from the Orient.

Countries producing silk. Among the countries producing the largest amount of raw silk, Japan, China, and Italy lead, and practically all of our raw silk is imported from these countries.

Japan. In the amount and quality of raw silk produced, Japan leads the world. To overcome the difficulties of the industry, she is using every available means, for instance, improvement of sericulture and exhaustive research on perplexing problems of cost and competition. Already there has been a marked improvement in the development of sericulture in the Japanese Empire.

China. The progress of sericulture in China has been much slower, the Chinese methods being more primitive. The silks, as a result, are inferior in quality to those of the Japanese. This inferiority is due largely to the ravages of disease among the silkworms.

The best Chinese silks have come from the Canton district. In spite of civil wars and political chaos, there was, in 1927, a marked improvement in Chinese sericulture. The best indication of this is the work carried on in the larger colleges of China, which is materially assisted by the Silk Association of America. Perhaps more significant still was the visit of a representative of Chinese silk-merchants to the United States. He came for the purpose of learning at first hand the American requirements for raw silk and silk fabrics, and of assuring the manufacturers of the United States that the silk-producers of South China are willing to coöperate in every possible way.

Shanghai is an important silk-market for tussah silks and silk wastes. From the Tsatlee district come silks which are famous for their strong and lustrous filature. American manufacturers, however, have been concerned about the small amount produced. Recently a number of modern filatures have

been added, resulting in a better quality and a larger production. To assist in this development, a branch of the United States Testing Company has opened a conditioning house in Shanghai.

Italy. The Italian industry also has been handicapped by the labor problem, which has caused a decrease in production. Through various agricultural organizations, the government is investigating conditions, and has appointed a commission to improve the industry. The National Silk Corporation is also undertaking to promote sericulture through research and the expansion of the industry throughout Italy and her colonies. The principal provinces for sericulture are Lombardy, with Milan as its center; Piedmont, with Turin as a center; and Venetia.

Other countries producing silk. Like Italy, France has suffered because of the high cost of labor. Although she is doing all in her power to stimulate interest in the industry and to increase her yield, the supply falls far short of the demand. France imports large amounts of silk from Japan, China, Italy, and the Levant. Lyons is the principal manufacturing center. While producing only small amounts as compared with other countries, Spain, the Levant, Russia, and India are trying to improve conditions and to increase their yield.

Linen. Prior to the World War, linen was one of the standard materials, universally used for household purposes, for dresses, and in surgical work. During the World War there was a decided setback in the industry, resulting from the destruction of the flax fields and the linen factories in France and Belgium. Since the Irish mills were worked to capacity in producing linen for airplane wings, there was very little all-linen cloth manufactured and the prices were almost prohibitive.

Countries producing linen. Our leading imports of fine linen come from Ireland, France, and Belgium; the coarser linens, from Russia.

Decline in the Irish production of linen. For several years before the War, there had been a gradual decline in the Irish production, and since 1918 there has been an alarming decrease in the amount of acreage devoted to the production of flax—a decrease of over 80,000 acres. This means a shortage of about 50 per cent in the production of linen fabrics manufactured in Ireland.

One reason for this decrease is competition on the Continent. Before the great conflict, the machinery used in the mills of France and Belgium was out of date, a condition which increased the cost of manufacture. After the War, the mills which had been destroyed were replaced with up-to-date plants. This has caused a revival of the industry in these two countries which promises to make them formidable rivals in the linen markets of the world.

Furthermore, consumption in the United States is not as great as formerly. In 1925, the amount of linen materials brought into the United States was 30 per cent less than in 1913; this was a startling reduction when we consider our natural increase in population and wealth. This decline cannot altogether be explained. Perhaps the high tariff, ranging from 35 to 75 per cent, is one reason. Another may be the substitution of cotton for linen in the household, particularly for bed and table linens, and the substitution of silk for sheer cotton fabrics in underwear and dress materials. Doubtless, also, the lack of stabilization of prices abroad has had its effect.

Russia produces most of the coarse linen crashes. For the most part, these are woven on hand-looms by the peasant women and are not bleached. Comparatively small amounts are exported to the United States.

Cotton. The United States produces a larger amount of raw cotton than any other country, using about one-half of her own crop and exporting the remainder. Among other countries producing are India, China, Egypt, and Brazil.

The finest long-staple cotton is the Sea Island. Unfortunately, this crop has suffered to such an extent from the boll-weevil that it is almost extinct. It is estimated that the loss amounts to millions of dollars annually. As a substitute, meade cotton, which has a long staple, and which matures earlier, is being used successfully.

Competition with rayons. Over a period of approximately five years, cotton has had to face competition with the rayons in the United States and Europe. This, however, affects only the higher grades of cotton, and not the lower grades, which are most extensively used and therefore constitute the bulk of the world's production and consumption of this material.

Increase in the prices of cotton. The price of cotton is much higher than it was before the War, but somewhat lower than it was four years ago. In 1914 the average price of the raw material was 12½ cents per pound. At the present time, however, raw cotton is bringing 21 cents per pound. Among the reasons for this increase in price are (1) the high cost and scarcity of labor, (2) the increased cost of transportation, and (3) the ravages of the boll-weevil.

Cotton, a universal fiber. With England a close second, France manufactures the best qualities of cotton dress materials. In the United States, the quality of these goods is improving to such an extent that some of our products rival those of England and France. Until recently, all the better grades had been produced in and around the New England States. With the trend of the cotton industries to locate nearer the sources of production, the Southern States are rapidly improving the quality of their output. The volume of goods pro-

duced at the present time is greater in the South than in the North. At present, cotton is utilized for so many different things that it has become the universal fiber. Cotton dress materials are now more beautiful in texture, color, and design than ever before. In the manufacture of such things as automobile tires, typewriter ribbons, some of the rayons, and coverings of electric wires, cotton fiber is now extensively employed. Undoubtedly cotton is the universal fiber, and is destined to play a large part in commerce, not only in the United States but throughout the world.

The rayons. Since 1910, there has been an almost phenomenal growth in the production of artificial silks or rayons. In 1927, the world production was estimated at 265,911,000 pounds, while in the same year the production in the United States rose to 75,000,000 pounds. For the future, a still greater increase in output may be safely predicted.

World production of rayons. In 1926, the United States ranked first in production and consumption; Italy, second in production only; Germany, third in both production and consumption; Great Britain, fourth; and France, fifth. The United States imports a large amount of rayon yarns. While the European yarns are less fine, they are beginning to show a marked improvement in texture.

Improvement in the quality of rayons. One of the most noticeable improvements in rayons is the making of finer sizes of yarn. This will probably mean an increase in the use of rayons as dress materials, the coarser sizes being used for underwear.

In fineness of filament, tensile strength, softness, suppleness, or luster, rayon cannot as yet compete with silk. Although, in combination with silk, the rayons are being used more and more for dress materials, there is no immediate danger of the rayons' replacing silk, as the demand for the latter is much

greater than for the former. According to statistics, the production of cotton far exceeds the production of rayons. In all probability, however, the rayons are being used more as substitutes for cotton than for silk, with the possible exception of the tussah silks.

In the future, we may expect, from present indications, an increase in the amount of rayon produced and in the uses made of it. Along with this, there will be a corresponding improvement in the size and quality of the yarn itself.

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PART II

YARNS

CHAPTER VIII

HISTORICAL DEVELOPMENT

The making of yarn for cloth is one of the oldest of the textile industries. The development of the industry, from the time when it was carried on with the use of crude implements by most primitive peoples of all ages and countries, to the present day with its complicated automatic machinery, is most interesting.

Carding. In all probability, the carding of the fibers in preparation for spinning is a custom as old as the actual spinning of the yarn. It consists in opening up the fibers and combing the tangled mass into a continuous loose roll called a *sliver*.

Hand carding. The carding was first done by the fingers alone. The fibers were disentangled, cleaned, and made into a roll. This method was later improved upon by the use of hand cards, which consisted of two thin, flat, rectangular pieces of wood with handles. One side of each of these pieces of wood was covered with leather, in which were numerous fine wires or teeth, called *clothing*. These wires were so bent that the points turned toward the handles of the cards. The fibers were placed between the cards and thoroughly combed until the mass was clean and fluffy. The lap was then placed on the back of the card, which was held in the left hand and made into a sliver with the back of the other card.

First roller card. Lewis Paul, in 1748, invented a pair of revolving cylinders, covered with wire clothing. By this process it was possible to card more rapidly than with the hand cards,

even though the fibers were fed by hand and the slivers were short. Later, Sir Richard Arkwright conceived the idea of feeding the cotton in a wide lap to the carding machine and passing it on to a funnel, where it was converted into a sliver. Still later, Arkwright invented a doffer, by which the sliver was removed from the machine.

Modern carding machines. There are two general types of modern carding machines: those used for cotton, and those used for wool. Cotton is carded on a revolving flat card, which is much simpler in construction than the wool-cards. There are two kinds of wool-cards: those for woolen yarns, and those for worsted yarns. The fibers for woolen yarns usually pass through three separate carding machines—the first and second breakers, and the finisher. Those for worsted yarns pass only through the first breaker.

Spinning. The principles of spinning yarn have been the same from prehistoric times down to the present. These principles include the drawing out of the fibers, the inserting of a twist, and the winding of the spun yarn on the spindle.

Hand spinning. The most primitive type of spinning was done by hand. The fibers were attached to a straight stick, called a *spindle*. As the spindle was twirled by the spinner the fibers were twisted into a strand. The spindle was then dropped, and as it dropped, the strand was drawn out. When the desired length was drawn out and twisted, it was wound on the spindle and fastened, and the operation was repeated. This method is still used by primitive peoples and in our own country by the Navajo Indians. The first improvement used in connection with the spindle was a weight, called a *whorl*, which was attached below the spindle to steady it when it was dropped.

Gharka or teakwood spinning-wheel. The method of spinning with the spindle alone was very slow. The first wheel of which there is a record is the *gharka*, a crude wheel which was

used in India. It consisted of a flat board, having a large wheel at one end and an upright, holding the spindle, at the other. The wheel and the spindle were connected with a band or pulley. The spinner, who sat on the ground, turned the large wheel by a crank. This method produced a very coarse yarn.

Wool or jersey wheel. This wheel was invented early in the fourteenth century. It consisted of a standard on three legs, with a large wheel at the back. In front, on an upright, there was a small wheel and a spindle. The large wheel was connected with the small wheel by a cord or pulley, while the small wheel was connected with the spindle. The large wheel was turned by hand, first in one direction, when the slivers were drawn out and twisted, then stopped and turned in the opposite direction in order to wind the yarn on the spindle. This was called *intermittent spinning.*

While spinning, the spinner carried a distaff, a straight stick, on which the carded slivers were wound. This was usually thrust through the belt or carried under the arm of the spinner. In Germany, the distaff was set on a flat board in an upright position, and placed near the wheel. This was called a *rock.*

Flax or Saxony wheel. This was invented in Germany, by Jurgens, about the middle of the sixteenth century. It consisted of a standard, on three legs, connected with a treadle underneath. On top and at the back, there was a large wheel. In front on an upright, a spindle with a bobbin and flyer was mounted. In front of the spindle on another upright, a distaff held the carded yarn. The treadle was connected with the wheel, which in turn was connected with the spindle by a cord. The spinner sat at the wheel and started it by placing her foot on the treadle. This started the spindle with its bobbin and flyer. The yarn from the distaff was drawn out, slightly twisted and guided to an eye in the end of the spindle, carried over a hook in the flyer, and fastened to the bobbin. The mo-

tion was continuous, as the drawing, twisting, and winding were done simultaneously.

Spinning-jenny. While spinning with the wheels was a great improvement over hand spinning, still it was a very slow process, and the demand for yarn exceeded the supply. It was thought that an increased number of spindles on the wheel might increase the output. This change was tried, but was not successful. The first invention that was really an improvement over the wheel was the spinning-jenny, invented by James Hargreaves, in Lancashire, England, about 1765. This machine made possible the spinning of several yarns at one time. It was an oblong frame, having on top at the back a large wheel which was turned by a crank. In front, a carriage on wheels was pushed by hand back and forth on a track. Underneath, in front, there were from eight to sixteen spindles. Back of the spindles, a cylinder was connected by a band with the spindles. Back of the cylinder was a row of from eight to sixteen bobbins, on which the roving was wound. The operator turned the wheel and at the same time pushed the carriage forward, thus drawing out and twisting the sliver. As the carriage was drawn back, the yarn was wound on the spindles. This was the progenitor of the modern mule spinning.

Arkwright's water frame. In 1768, Richard Arkwright combined in his water frame the drafting rollers of Lewis Paul with the principles of the flax wheel. This was an upright frame. The bobbins of roving were placed at the top, back of the drafting rollers. In front, at the bottom, stood a row of spindles, each with a flyer. At the side, a large wheel was operated by water power. This was the progenitor of the modern upright spinning frames.

Crompton's hand mule. In 1779, Samuel Crompton invented a hand mule, using the principles of the spinning-jenny. It consisted of an oblong frame, on top of which were draft-

ing rollers, and in front of which was a large wheel turned by a crank. Underneath, a carriage on wheels moved back and forth on a track. On the carriage were the upright spindles. As the wheel was turned, the carriage was sent forward, drawing out the fibers through the drafting rollers and twisting them. As the carriage was drawn back, the yarn was wound on the spindles.

Modern mule spinning. There are two kinds of modern spinning mules: (*a*) one for woolen yarns, and (*b*) one for worsted yarns. Both are based upon the principles of Crompton's mule and are alike in general principle. Both have rollers which guide and feed. The upright spindles are placed on a movable carriage which travels back and forth on a track from sixty to seventy inches long. The tension is maintained in winding by faller wires. The motion is intermittent. The drawing and twisting are done on the outward journey of the carriage and the winding on the return.

a. The woolen mule. The roving on the woolen mule is placed on jack-spools at the back of the machine. In front are feed rollers, which do not draw out the fibers, but regulate the tension. The spindles are so placed on the carriage that they slant forward. The spindles, with the guide wires, revolve, and as the carriage moves outward, the roving is drawn out and twisted. The carriage stops automatically for a second, and as it is drawn back, the spun yarn is wound on the revolving spindles.

b. The worsted mule. In the worsted mule, the roving is placed on shells in the back of the machine. In front are two faller wires which draw out the fibers. In front there are two sets of drawing rollers. Between these rollers are two other sets of rollers which regulate the tension. The spindles with the guide wires revolve and twist the fibers as the carriage moves outward. When it stops, the yarn is backed off the top of

the spindle. As the carriage is drawn back, the spun yarn is wound on the spindles.

Modern upright spinning frames. The upright frames which are also used in modern spinning are based on the principles of Arkwright's water frame. There are three types: (*a*) the ring frame; (*b*) the cap frame; and (*c*) the flyer.

a. The ring frame. In the ring frame, the roving passes through the drawing rollers and is drawn out, then passes through a traveler to the bobbins. The spindles and the traveler revolve rapidly. As the traveler turns, it not only twists the yarn but winds it on the bobbins. The winding is regulated by a lifter or platform which carries the ring and the traveler.

b. The cap frame. In the cap frame, the roving passes through the drawing rollers and is brought down through an eye to a guide rail, and over the cap to the bobbin. As the bobbin turns, the thread is wound rapidly about the cap, twisting it and winding it.

c. The flyer. In the flyer frame, the roving passes through the drawing rollers, is brought down through the eye of a guide to the end of the flyer, and is attached to the bobbin. As the spindle revolves, the flyer also turns, and the yarn is twisted. The tension of the yarn turns the bobbin on which the yarn is wound.

CHAPTER IX

INDUSTRIAL DEVELOPMENT IN THE UNITED STATES

The textile industries in the region which is now the United States began in a primitive way among certain tribes of Indians. With the coming of the white man, the industries were developed first in the home, where they were carried on by the different members of the family. Later these home industries developed into a more complicated domestic system which continued through the colonial period. After the Revolutionary War, the factory system, which came with the Industrial Revolution in England, was developed in the United States.

Primitive industries. As far as history records, the American Indians who carried on these primitive industries were, with a few exceptions, lacking in the energy, initiative, and industrial efficiency which are essential factors in the development of a nation. With the exception of the well-organized community life of the Cherokee Indians in the South, the Pueblo Indians in the Southwest, and the Iroquois in New York, there had been very little industrial and social advancement before the coming of the white man. Such textile industries as the spinning and dyeing of yarns and the weaving of rugs and blankets, some of which were very artistic in design and color, were carried on by the Navajo and Zuñi Indians much as they are to-day.

Organized home industries. The coming of the white man in the early settlements in the colonies brought about the fam-

ily industries, which were carried on in the home. At this time, there was neither the need nor the incentive for large production. The coarse materials were made in the home, but the more elaborate and fine materials were imported from England and other countries.

With the pressing demand for greater production, particularly in England, there was a tendency to break up the family tradition and to organize an industry on a larger scale. Consequently artisans or skilled workers in groups were brought together in the home. Not only did they weave the cloth, but they also dyed and fulled the wool materials. All of the cloth woven was made especially for the consumer.

The domestic system. The home industries were followed by the domestic system, which was developed along two lines: (1) the specialization of the individual in his particular trade: and (2) the division of the crafts, including weaving, into distinct trades by separating dyeing and fulling from weaving. While all this work was still done in the home, it differed from the home industries, because the worker no longer was an independent craftsman working for the consumer. Instead, the raw materials were supplied by a merchant who paid for the labor and marketed the product. Common in the early part of the eighteenth century, this system lasted up to the beginning of the factory system.

The colonial industries. The colonial industries were controlled to a certain extent by Parliamentary legislation. To the Board of Trade and Plantations was intrusted the oversight of all the British possessions in the American colonies. This board was instructed to report the condition of the plantations, and to make any recommendations for legislation. In addition, it also received any complaints or petitions. The immediate concern was to keep all industries in channels which would furnish a revenue for the mother-country and to provide raw materials

for manufacture in England. On the other hand, the colonists were expected to buy materials imported from the mother-country. To pay for the imported goods was difficult, as it was sold at a big profit and the commission was high. During the period of the civil wars in England, there were no immigrations from England to the colonies. To make matters worse, there was a check on gold currency. As a result, the colonists' supply of money was exhausted, and they had no way of paying their debts to England.

In order to overcome this difficulty, the General Court of Massachusetts decided in 1640 to encourage and promote domestic manufacture. In 1645 an appeal was made to the farmers to increase the number of sheep. With raw wool available, the colonists were soon able to manufacture homespun for their own consumption. A few years later, every family was required to furnish at least one spinner, who was expected to spin three pounds of yarn a week for thirty weeks. A fine of twelvepence was imposed for each pound short of the required amount.

Restrictive laws. As long as the materials made by the colonists were confined to coarse cloth for family use, the British government did not interfere. When a little later, however, the colonists began to weave a finer and better material, the English wool-manufacturers became alarmed, and in 1699 Parliament passed the *Woolen Act*. This act prohibited the exporting of woolen goods from the colonies, the selling of goods from one colony to another, and the selling of goods from one town to another within the colony. The following year, Parliament removed the duty on imported woolens, with the result that there was a decrease in the manufacture of wool cloth in the colonies, and trade with England was resumed and continued for several years.

At the close of the French and Indian Wars, England's possessions in America and India had increased to such an extent

that it was necessary to establish a new system of colonial government to take care of the added responsibilities. The Prime Minister, supported by George III, decreed that commercial relations must be enforced; therefore, there was stationed in the colonies a standing army of British regulars which was to be partly maintained by taxes imposed on the colonists.

The Sugar Act. The first tax imposed was on sugar, molasses, coffee, wines, silks, and other articles. It resulted in cutting off trade with the West Indies, thereby seriously embarrassing domestic trade.

The Stamp Act. As the amount of revenue derived from the Sugar Act did not meet the expectations of Great Britain, Parliament passed the Stamp Act in 1765, requiring that all licenses, deeds, wills, contracts, and the like, and all printed matter should bear stamps, the cost varying from a halfpenny to forty pounds. A committee was appointed to distribute the stamps and to see that they were used. Fines varying from five to fifty pounds were imposed for neglecting to use them. This resulted in a protest. Believing that they were entitled to the same rights as the residents of Great Britain, the colonists declared that there should be no taxation without representation. A series of resolutions were drawn up by representatives from several of the colonies and submitted to the king, but without avail.

As a result, a boycott was instituted by the colonists. In the leading cities of the Colonies, merchants decided not to import any goods from Great Britain, and the consumers agreed to buy only such articles and goods as were manufactured in the colonies.

In 1751, societies were organized to promote the raising of sheep for wool, to discourage the killing of sheep for meat, and to develop domestic manufactures to take the place of imported goods. The British governors and officers were now con-

vinced that the colonists were in earnest. English manufacturers were not able to dispose of their goods; some of the English mills were closed and their operatives thrown out of employment. Becoming alarmed, these manufacturers sent to Parliament a petition for the repeal of the Stamp Act.

Repeal of the Stamp Act. The proposal to rescind brought about the longest and most bitter debate in the history of the British Parliament. Finally in 1766, the act was repealed.

The Declaratory Act. Just before the Stamp Act was repealed, the Declaratory Act was passed by Parliament. This act stated that the colonies and plantations should be subordinated to and dependent upon the British government. Rejoicing over the repeal of the Stamp Act, however, the colonists did not take this seriously and considered it only a threat. The government of Great Britain was now more determined than ever to derive a revenue from England's American possessions; late in 1766, therefore, the Sugar Act was revived. Parliament also passed a Mutiny Act, which required the colonists to furnish fuel, light, and lodging for the soldiers. Other revenue tariffs were imposed. All this culminated in a renewal of the non-intercourse act by the colonists, who agreed not to purchase goods manufactured in England. By this time the colonists were able to manufacture enough goods to supply their own demands. This step was closely followed by the tax on tea and the Boston Tea-Party, December, 1773. In March, 1774, Great Britain ordered the port of Boston closed. In September of that year, the Continental Congress met in Philadelphia and adopted a non-intercourse and non-consumption resolution which included all imports from England, the West Indies, and the East India Company. This boycott was vigorously enforced. In March, 1775, Parliament ordered additional troops stationed in Massachusetts, and the port of Boston was blockaded by the British fleet.

In April, 1775, the situation had become intolerable, and on the nineteenth the battle of Lexington was fought. This was followed in June by the battle of Bunker Hill, and in July of that year Washington took command of the American forces. In July, 1776, the Declaration of Independence was signed.

The Industrial Revolution in England. The Industrial Revolution began in 1770 and extended over a period of about seventy years. This involved the displacement of the domestic system by the factory system. It brought about (1) the invention of machinery in the textile field, at first only for carding and spinning and later for weaving; (2) an extensive division of labor, which resulted in an enormous increase in the output of textile products; (3) the building-up of towns of a different type, with large industrial populations; (4) changes from a social standpoint, the workers being grouped in factory towns, which resulted in the drawing of a distinct line between the laborer and his employer; and (5) the beginning of organized labor and the rise of a new class of capitalists.

Guarding her machinery jealously, England prohibited the exporting of machinery of any kind, or of any parts or any plan of a machine, out of the British Isles. Consequently the installation of machinery in the United States for manufacture did not take place until after the Revolutionary War.

Development of the factory system in the United States. With the signing of the Declaration of Independence, the colonial period came to an end. Declaring themselves free and independent of the British government, the united colonies became sovereign States. In March, 1789, with the adoption of the Constitution, the commerce of each State became the commerce of the United States and freedom of trade was established throughout the Union.

First factory in the United States. The first mill having machinery for carding and spinning was built and

operated by Samuel Slater in Pawtucket, Rhode Island, in 1790.

Born at Belper, Derbyshire, England, in 1768, Slater was bound out as an apprentice to Jedediah Strutt, a manufacturer of cotton machinery. During the last few years of his apprenticeship, he was general overseer in the making of the machininery and also of the manufacture of cotton cloth. Before his term of apprenticeship had expired, he saw an advertisement in an American paper, offering a bounty to any party who might be successful in securing machinery for cotton manufacture in the United States. Therefore he determined to go to America. He knew of the penalty imposed by the British government for taking plans, models, or specifications of machines out of the country; therefore he decided to make a careful study of the construction of the machinery so that he would be able to reproduce it from memory. In 1789, Slater came to the United States, and in December of the following year he started his mill in Rhode Island.

Progress of the factory system. The growth of the factory system indicates the importance of the textile and allied industries. At first progress was slow, because practically all of the machinery was operated by hand. The application of steam power to machinery was not general until after 1813.

Industrial expansion. At the beginning of the nineteenth century, the United States was primarily an agricultural nation. As a result of the embargo and the non-intercourse acts, followed by the War of 1812, the people of the United States were thrown on their own resources. Thus a new impetus was given to domestic manufacture. Shipping interests were at a standstill; consequently much of the capital which had been invested in shipping was withdrawn and reinvested in textile industries.

Use of machinery for the manufacture of cotton. The invention of the cotton-gin by Eli Whitney in 1793 revolutionized

the cotton industry in the United States. As a result of this invention, thousands of acres of land in the South were given over to the cultivation of cotton. The mills in the New England States began to manufacture cotton yarn and cloth on a large scale, making possible the exporting of raw cotton to the other countries.

Early in the nineteenth century, spinning-mills, which were direct offshoots of Slater's mill in Rhode Island, were opened in Connecticut and New York. Other cotton-mills were built in rapid succession in the Eastern States. The weaving of cloth, however, was still done on hand-looms. In 1807 there were only fifteen cotton-spinning mills in operation, while in 1811 there were eighty-seven mills in operation, producing over 2,000,000 pounds of yarn annually. The first machinery operated by water power was in a spinning-mill in Balston, New York, in 1810.

In 1814, the first mill in which spinning, weaving, and printing were all accomplished in one building was established by Francis Lowell in Waltham, Massachusetts.

The demand for machinery operated by steam power brought about an increase in the manufacture of iron, as iron formed the foundation of all machinery. Still another determining factor was some means of transportation. The opening of the Erie Canal in 1835, the extension of the railroads in the United States, and the development of waterways added much to the demand for an increase in textile manufacture.

During the period between the War of 1812 and the Civil War, remarkable progress took place in the amount of cotton exported, in the invention of machinery equally as good as that used in England, and in the volume of cotton goods produced.

Growth of manufacture of wool. While there was a rapid growth in cotton manufacture, the production of wool had been slow because of the scarcity of raw wool. Our isolation from Europe, preceding and during the War of 1812, brought about

a realization of the necessity for a domestic supply of raw wool. When our farmers began to import merino sheep from Spain, woolen mills were soon established, the machinery used for cotton being readily adapted for woolen manufacture. In 1828, a mill operated by water power was established in Pittsfield, Massachusetts.

Following the War of 1812, a series of high tariffs afforded protection to the manufacturer for a number of years. As a result, capital increased, the manufacture of cotton and the manufacture of iron were established on an assured basis, and there was a rapid growth of factory communities.

During the period between the War of 1812 and the Civil War, the wool industry had not increased to the same extent as the production of cotton. There were three reasons for this: (1) the demand for raw material was greater than the supply; (2) the quality of domestic wool was not as good as that of imported wool; and (3) the duty on imported wool made its price almost prohibitive. For these reasons, the manufacture of domestic wool was confined to coarse broadcloths, flannels, and blankets.

Southern expansion. Between the close of the Civil War and the beginning of the twentieth century, the South enjoyed a period of remarkable expansion in its cotton manufactures. While the New England States were still the chief center of the cotton industries, there were a number of advantages for Southern manufacture over Northern. As the factories in the South were near the source of supply of the raw material, the transportation costs were less. The poor whites of the South afforded cheap labor, and nature provided water power in abundance. One of the serious drawbacks of cotton manufacture in the South at this time was the employment of child labor. This, however, has been done away with to a large extent by the compulsory education laws of the different States.

Present Southern trend. During the past six years, many Northern manufacturers have either moved their plants South or established branches there. About eighty mills in the North have either gone out of business or are about to do so. One of the reasons for this is the obsolete character of the machinery in some of the Northern mills. Instead of installing new machinery which would increase production, the mills have been worked overtime and old machinery worked overtime does not last long. Still other advantages held by mills in the South are milder climate and freedom from the labor laws which Northern States have adopted.

At first the moving of the mills South and the establishment of new mills were confined to the Southeastern States. Of late, however, the movement has spread throughout the South, and the volume of cotton goods produced in the South now exceeds that of the North.

The Southern trend has not been confined to the cotton industry alone. In Tennessee, Virginia, and Georgia, some rayon-mills and silk-mills have been opened, and a number of full-fashioned hosiery mills have also been moved South from Pennsylvania.

CHAPTER X

PROCESSES OF PREPARATION AND MANUFACTURE OF WOOL

In the manufacture of wool yarns, there are two distinct processes: those for woolen yarns, and those for worsted yarns. The following processes, however, are common to both the woolen and worsted yarns.

Shearing. In the United States, sheep are now sheared by machines operated by electricity. A long covered shed is erected, and the clippers are fastened on each side of the machine. There are as many men to operate the clippers as there are clippers on the machine. The sheep are driven down a chute into a corral, from which they are brought in one at a time to the shearers. The legs of the animal are tied and the wool is so clipped that it can be taken from the sheep in one large piece. Each fleece is rolled up and tied. The wool is sent to the factories in bundles of from 100 to 150 pounds each.

Sorting. The bales are opened and the fleece separated. The wool on the neck, sides, and shoulders is the best. The most inferior is from the head, belly, and legs. The sorter throws the different grades into marked bins.

Washing and scouring. This is done to remove the grease which is excreted from the skin, and the dirt which adheres to the fibers. The wool is washed in a series of four connecting tanks, each containing an alkali bath. The fibers are washed in the first tank and rinsed in the others. Rollers are connected with the tank, and the wool is passed with rakes

from one tank to the next. The wool as it comes from the last tank is soft and white. If the wool is to be fiber-dyed, it is sent to the dyeing machine; if not, it is dried by forcing hot air through the fibers. Usually about 16 per cent of moisture is left in the wool.

Burring and carbonizing. If the scoured wool contains burrs or any foreign matter that adheres to the fibers, this is removed either with the burr picker or by a carbonizing process. In the burr picker, the wool fibers are made into a sheet, against which rotating blades beat the wool and break the burrs into small pieces which fall into a grating under the machine. If it is carbonized, the wool is immersed for several hours in a solution of either sulphuric or hydrochloric acid. It is stirred frequently, dried, and placed in an air-tight chamber, at a temperature of 75 degrees centigrade. This process burns out the vegetable matter, leaving the wool intact.

Blending. Fibers may be blended as to color or quality. Fibers of shoddy may be mixed with virgin wool, or cotton with wool. Different grades of wool may also be blended. The object is to secure the desired quality and weight. The blending is done by spreading the wool out in thin layers one on top of the other, and passing these layers through a teaser. The teaser, which is composed of large and small rollers studded with pins, opens up the wool, pulls it apart, and thoroughly mixes it. This process is repeated several times. When the wool leaves the machine, it is soft and fleecy.

Oiling. In the scouring process, the natural oil has been removed. As a certain amount of oil is necessary to keep the fibers soft and elastic, the fibers are sprinkled with oil, usually lard or olive oil.

Manufacture of woolen yarns. Woolen yarns are made from the short fibers of wool, which are so carded that they

lie in all directions and are loosely twisted. They go through the following processes: (*a*) carding and (*b*) spinning.

a. Carding. There are three carding machines, the first and second breakers, and the finisher. Each machine consists of cylinders of different sizes, covered with fine teeth, revolving at different speeds. The wool is carried from one cylinder to the next and emerges from the finisher in a soft, fluffy sliver.

FIG. 22
WOOLEN YARN

FIG. 23
WORSTED YARN

b. Spinning. The roving is drawn out and twisted on the mule spinning frame and wound on bobbins, ready for the loom.

Manufacture of worsted yarns. Worsted yarns are made from the long fibers of wool, which are so combed that the fibers are parallel and are tightly twisted. The processes of manufacture are as follows:

a. Carding. The fibers are usually carded only with the first breaker, where they are so carded that they lie in parallel order.

b. Gilling. In the gill boxes the fibers are drawn out, slightly combed, and doubled into slivers. Four of these slivers are rolled into a ball and taken to the combing machine.

c. Combing. The object of combing is to remove the short fibers or noils and to straighten the remaining fibers. In the United States, the combing is usually done on the Noble comb, which is a circular machine. Eighteen balls of slivers are passed around the comb. The ends of the slivers, four from each ball, are passed through the ring on the edge of the circle and through a feed box to the combing apparatus. This consists of a large revolving circular comb, having several rows of pointed teeth. On the opposite sides of the large circle are two smaller circles; these have several rows of teeth, which come in contact with the teeth in the larger circle and comb the fibers parallel. The short fibers, or noils, are combed out, and the slivers, two from the large circle and two from the small circles, are united. The resultant sliver is called a *top.*

The combing is followed by another gilling, a combing process, the purpose of which is to increase the parallelism and to reduce the strands to a uniform size. Three or more slivers are united and the finished top is wound into a ball by a balling head attachment.

d. Drawing and doubling. The finished tops are now sent to the drawing machine, where the tops are drawn out and a slight twist is inserted. This process is repeated as often as necessary according to the size of the yarn desired.

e. Spinning. Worsted yarns may be spun either by the English or Bradford system or the French system. In the former, the wool is oiled before combing, while in the latter it is dry-spun. Dry-spinning produces fuzzier yarn than that produced by the English method. In spinning, either the mule or the ring frame may be used, depending upon the kind of yarn desired.

CHAPTER XI

PROCESS OF MANUFACTURE OF SILK

Most of the silk from cultivated cocoons and a large percentage of that from wild silk cocoons is reeled. The processes are as follows:

Sorting. After the cocoons have been spun by the worm and the chrysalis has been killed so that the moth cannot escape, the cocoons are sorted according to texture and color, and the outside fibers are removed.

Reeling. The cocoons are placed in hot water to soften the gum, and are then brushed. The fibers adhere to the straws of the broom, and they are unwound until a single fiber shows. Four or more cocoons are placed in a basin of hot water below the reel, the number depending upon the size of the yarn desired. An end from each cocoon is carried through two separate perforated agates a few inches above the basin. These ends are brought together, twisted several times, separated again, and passed on to be wound on the reels. All of the silk is reeled in the countries where it is produced.

Conditioning. The hygroscopic property of silk is very great. It will absorb as much as 30 per cent of its weight of water. Since the buyers in this country require that the excess of moisture be removed, this is done in the conditioning houses. Here a number of samples are taken from each bale, weighed, and placed in desiccators, where they are thoroughly dried. The normal amount of moisture, 11 per cent, is then added, and the samples are weighed again, the last weight forming the basis for buyers.

Degumming. The reeled silk as it comes to this country is harsh and stiff because of its gum coating. This gum must therefore be removed. It is first softened by soaking for several hours in a warm soap solution. When dry, the skeins are placed on reels in the winding frame and wound on bobbins. The filaments pass from one bobbin to another, between two parallel plates which are so closely set that only the silk can pass through. The object of this process is to remove the dirt and adhering foreign matter.

Throwing. This process is analogous to spinning. Reeled silk is converted into a yarn. The bobbins are placed in a doubling frame, where a number of single threads are brought together to make a thread of the required size. This is done by carrying the threads from several bobbins through a guide and winding them on a single bobbin. They are then taken to the spinning frame, where they are twisted. The amount of twist depends upon the purpose for which the silk is to be used. Yarns used for the warp are called *organzine*. They are usually made of singles, which are first twisted a number of times, with a right-hand twist. Two or more of these twisted threads are then doubled and twisted in the opposite direction. Those threads which are used for filling are called *tram,* and are made of untwisted singles, very loosely twisted.

Stripping. In this process, the skeins of silk are worked in a boiling, soapy water until the gum is removed.

Weighting of silk. Because of its hygroscopic property, silk has a great affinity for dyestuffs and also for solutions of certain metallic salts. In the boiling-off process, silk loses from 5 to 30 per cent of its weight. To bring up this weight, without perceptible injury to the fiber, a solution of one of the metallic salts may be added. This gives the fiber more body, luster, and finish, and also increases its affinity for certain dyestuffs. An

excessive amount, however, injures and weakens the fibers. The process of weighting is as follows:

The silk gum is removed by boiling the silk for about one hour with pure olive-oil soap. It is then rinsed through several changes of hot water to remove the gum and oil. It is next placed in a bath of water acidified with either muriatic or hydrochloric acid, in order to neutralize the alkali. Thence it goes to a bath of bichloride of tin or stannic acid, at a strength of 30 degrees Baumé, where it is soaked from forty-five minutes to one hour. When the silk has taken up as much of the solution as it will absorb, it is removed from the bath, wrung out, washed in four or five changes of water, and slightly wrung again. It is then placed in a bath of sodium phosphate for one hour, wrung out, and rinsed in two changes of water. If an increased weight is desired, it is placed in another bath of chloride of tin and sodium phosphate. This is followed by a bath of silicate of soda at a temperature of 135 degrees Fahrenheit. The silk is wrung out, passed through two rinsings of warm water, and then placed in a 15 per cent solution of olive-oil for one hour. After this, it is washed in two water baths, and then in a bath of water slightly acidified with muriatic acid.

White or light-colored silks are weighted with sugar or with acetate of lead. A solution of lump sugar is placed in water in a copper container, where it is heated and dissolved. The silk is then saturated in the solution and dried. One dipping will increase the weight about 12 per cent. In the lead acetate solution, each dipping increases the weight of the silk about 8 per cent.

Dyeing of silks. Silks are dyed with direct colors, with acid dyes, or with developing dyes. Most of the black silks are dyed with logwood. The silk is first mordanted, with either iron nitrate or tannin, and then placed in the logwood bath.

Spun silk. The fibers from cocoons which have been pierced by the moth cannot be thrown, because the fibers are too short. They are carded and spun as cotton is carded and spun. The waste silk comes to this country "in the gum." At the factory, the gum is first boiled off. The fibers are then washed and dried, next loosened and beaten to open them up and free them from any foreign matter. In order to straighten out the fibers, they are carded, and then they are ready for spinning. The long fibers are called *laps* and the short fibers *noils*. The laps are drawn out, spun, and woven; the noils are used only for the cheapest materials.

CHAPTER XII

PROCESSES OF PREPARATION AND MANUFACTURE OF COTTON

Cotton-seed is planted from March until May, depending upon the locality, and begins to mature in July. The seeds are sown by machines, in rows about four feet apart. When the plants are about three feet high, they are thinned out or chopped with a hoe, the stronger plants being left about twelve inches apart. In June and July, the plants begin to blossom. Often blossoms, bolls, and ripe cotton may be found on the plant at the same time.

Usually the bolls on the lower branches ripen first, followed by those in the middle of the plant, and then by the bolls on the top of the plant. The fight against the boll-weevil begins as soon as the bolls form. The cotton is picked as soon as the bolls ripen. The season lasts from July until frost, which usually occurs in November or December. The picking is done by hand. The average amount picked in a day is from 200 to 250 pounds. When the cotton is dry, it is put in a wagon and carried to the gin.

Preparation. There are several steps in the preparation of raw cotton for manufacture into cloth. These are: (*a*) ginning; (*b*) baling; (*c*) bale-opening and breaking; (*d*) picking.

a. Ginning. The object of ginning is to separate the fiber from the seed. There are two kinds of gins: (1) the saw gin, which is most commonly used, but which tears the fibers somewhat; and (2) the roller gin, which is used for the long-staple cottons.

1. The saw gin: The cotton is fed through a chute to the gin, which consists of a series of circular saws, from forty to eighty on a shaft. These saws revolve rapidly and pull the fiber from the seed. The seeds drop below, and a revolving brush brushes off the cotton fibers from the teeth and carries them to a flue, from which they go to the condenser. This will gin about 5,000 pounds of cotton a day.

2. The roller gin: This gin is used for Sea Island and other long-staple cottons. The saw gin tears and tangles the cotton fibers; therefore the roller gin is used for fibers which are to be used in the manufacture of fine yarns. This method is much slower than that of the saw gin, as the roller gin will gin only about 1,000 pounds a day. The roller gin consists of a hopper with leather-covered rollers in the bottom. These rollers seize the fibers, while a doctor, or fixed blade, draws the fibers under the blade away from the seeds, which are combed away from the doctor and fall through slots in a feeding table. The fibers are brushed off the rollers by a revolving brush.

b. Baling. The fibers are made into bales at the gin. The cotton is put in a large box the size of the bale, where it is pressed into as small a space as possible. It is then covered with bagging and bound with iron bands. The American bale is fifty-six inches high, twenty-seven inches wide, and forty-eight inches deep. If the cotton is to be shipped, it is usually compressed into a much smaller bale by a Morse lever press. The cotton is placed in the press, where a sudden pressure of 5,000,000 pounds per bale greatly reduces the size. The bale is then recovered with burlap and bound before the pressure is removed.

c. Bale-opening and breaking. The bands are broken and the covering is removed. The cotton is then opened up, and the hard lumps are broken up. The cotton from several bales is then mixed to make a uniform grade.

d. Picking. There are three kinds of pickers: the breaker picker, the intermediate picker, and the finisher picker. The object of all three is to beat out the foreign matter, to clean, and to make the fibers somewhat parallel. The cotton leaves the last picker in the form of a lap.

Manufacture. The processes of cotton manufacture are as follows: (*a*) carding; (*b*) sliver lapping; (*c*) combing; (*d*) drawing; (*e*) slubbing; (*f*) spinning.

a. Carding. The cotton enters the carding machine in the form of a short lap about thirty-nine inches in width. The fibers are disentangled, cleaned, and drawn out into a thin layer. Passing them through an eye or between rollers then converts them into a narrow sliver.

b. Sliver lapping. If the fibers are to be combed, several of these slivers from the card are formed into a lap in the sliver lap machine.

c. Combing. The combing process is used only for very fine yarns or materials, or for thread. During the process of combing, the short fibers are combed out, and only the long fibers remain; it is therefore an expensive operation. In combing, the fibers are straightened and made parallel.

d. Drawing. The fibers are equalized by combining a number of them and laying them perfectly straight and parallel. This process is repeated as many times as necessary, according to the size of the yarn desired.

e. Slubbing. This is accomplished by the fly frames. The number of fly frames depends upon the number of the yarn to be made. The fly frames are all about the same in construction and principle, the difference being in the size of the working parts. They are the slubber, the intermediate, the roving, and the jack frames. As just listed, each in turn draws out and twists more than the one preceding. The jack frame is used only for very fine yarns.

f. Spinning. The final process of yarn-making is spinning. Here the roving is drawn out to the required size, and the desired amount of twist is inserted. There are two kinds of spinning for cotton: the mule, and the ring frame.

CHAPTER XIII

PROCESSES OF PREPARATION AND MANUFACTURE OF LINEN

Flaxseed is sown broadcast early in the spring, and is raked by hand. When the plants are two or three inches high, they are weeded by hand. The plant blossoms when nearly grown, and the blossom is blue in color.

The processes of preparation of flax fiber and its manufacture into linen are as follows:

Pulling. When the plants are ripe and the stalk has turned yellow, the plants are pulled by hand. If they are cut, part of the length of the fiber is lost and the sap runs out of the stalks, making the ends of the fiber blunt, instead of pointed and brittle.

Drying. To dry, the fibers are hung in bundles or piled in stacks out in the open for several days. Sometimes they are kiln-dried.

Rippling. The object of rippling is to remove the dry leaves and seed-pods. The process is accomplished either by hand or by machine. If rippled by hand, the bundles of flax are drawn across rakes or spiked boards, which pull off the leaves and seed-pods. In machine rippling, the bundles of flax are held against revolving cylinders which beat off the leaves and seed-pods.

Retting. Retting is a process of rotting away the outer layers of flax-straw in order that the fiber may be readily removed. There are several methods of retting. In Russia and Germany, the fibers are dew-retted. The flax fibers are spread

out on the grass and exposed to the action of the sun and dew for several weeks. This process gives the fiber a gray color. In Ireland, the flax fibers are retted in pools of stagnant water. The bundles of flax are immersed and weighted down under the water for several days. This gives the fibers a bluish color.

In Belgium, the flax is retted in streams of running water, usually in the River Lys, and is known as *Courtrai*. The flax is placed in open crates, the sides of which are covered with burlap, and which are weighted so that they are about six inches below the surface of the water. The retting process takes about fifteen days. The bundles of flax-straw are then taken out of the crates and spread out in the open fields to dry. When dry, they are stacked in tent-like stacks. This method is considered the best, as it produces a strong fiber, creamy white in color.

Another method of retting is with chemicals. Many experiments have been made with chemicals, but the results have not been very satisfactory. The chemicals injure the fiber, and the color is not good.

Breaking. The woody part of the stalk may be broken either by hand or by machine. In the hand break, the flax is laid across a row of slats, against which a beater is brought down several times. This breaks away the woody part, leaving the fibers in the bars. In the machine break, the flax is passed through fluted rollers, which break the woody part and eliminate a large amount of dirt.

Scutching. This is a further cleansing process to remove the woody part of the stalk. A machine composed of wooden blades beats out the woody portion, leaving the fibers fairly free.

Hackling. This is a combing process. There are really two processes: the first, which is called *roughing*, is accomplished by drawing a bundle of flax fibers through a set of upright teeth several times; the second process is accomplished on long

upright machines. The flax from the roughing machine is passed through a series of teeth, which comb the flax as it moves slowly through the machine. An attendant at one end of the machine receives the long fibers, which are called *line,* and places them in a second machine where they are combed in the opposite direction. The short fibers, or tow, which are left in the teeth, are removed by a revolving brush.

Sorting and cutting. The fibers are sorted by hand and cut. The middle cut, which is considered the best, is used for very fine yarns.

Spreadboard. The bundles of flax are laid on a traveling apron, so that the ends of the fibers overlap about six inches. They then pass to a board where they are combed through by a set of teeth, which produces a continuous sliver.

Drawing and doubling. The slivers are doubled and drawn out many times, the number depending upon the size of yarn required.

Spinning. Flax is spun by a method similar to that employed in cotton-spinning. In the case of fine yarns, however, the fibers must pass through a trough of hot water before spinning. This dissolves the natural gum and prevents breakage.

CHAPTER XIV

YARN COUNTS

The technical term for the sizes of yarns is *counts*. They are based on the number of hanks required to make a pound. The number of yard lengths varies with the different fibers and in the different countries.

Wool. The counts of worsted and woolen yarns differ. For the worsted yarns, the counts are based upon the number of hanks per pound. Each hank contains 560 yards. For example, a number 40 worsted yarn would contain 40 hanks of 560 yards each, or 22,400 yards to the pound. The numbers vary in size, as follows: 30s-40s coarse, 40s-50s medium, and 60s-100s fine. The standard is 60s. For the woolen yarns, different systems are used in different countries, two systems being used in the United States: the run counts, and the cuts, both of which are based upon the number of hanks per pound, though the sizes of the hanks differ. In the American run counts, each run contains 1,600 yards per pound. For example, a 4-run yarn would have 6,400 yards per pound. In this system, numbers 1-3 are coarse, 3½-5 medium, and 6-8 fine. In Philadelphia, yarn counts are based upon the cuts, which consist of 300 yards; the number of cuts to the pound determines the count. Cuts are expressed as 1/30s cut, for single number 30 yarns, and 2/30s cut for two-ply number 30 yarns. The numbers vary from 18, which is very coarse, to the fine, which is 40.

Silk. There are different systems of counts for reeled, thrown, and spun silks. The reeled silk count is based on the

metric and denier systems. A hank of raw silk containing 520 yards is used as a basis. The number of deniers in a hank determines the count or the size of the yarn. One ounce avoirdupois equals 533 deniers. The usual count in the United States is 13/15 deniers. Usually the fibers from five cocoons are combined in reeling for the standard count, 13/15 deniers. The thrown silk count is based on the Manchester Dram system. In this system, 1,000 yards of silk weigh one dram, or there are 256,000 yards per pound. The number of yards may be found by dividing 256,000 by the number of drams given. The count for spun silk is the same as for cotton. Eight hundred forty yards equal one pound of 1s counts.

Rayons. The rayon counts, like those for reeled silk, are based on the denier system. The sizes in the different kinds of rayons vary. They are usually in steps of ten, from fifty upwards. The number of filaments also varies in the different rayons. In the 150 denier, made from a 20 filament, the average size would be 7½ deniers.

Cotton. The size of cotton yarn is denoted by the number of hanks, each hank containing 840 yards and weighing one pound. Number 10s single would have ten hanks of 840 yards each or 8,400 yards in one pound. This would be expressed 2/10s or 10/2s, and 16,800 yards would weigh two pounds.

Linen. These yarns are counted by the number of leas in a pound. Each lea contains 300 yards; therefore a number 1 yarn would have 300 yards to the pound.

Determining number of threads per inch in materials. In counting threads, counting or pick glasses are used. A quarter-inch pocket glass is considered the best. It must be remembered, however, that there are more warp threads near the selvage than there are a few inches away from the selvage. It is therefore necessary to make several counts in different parts of the width before taking an average. In counting the

filling threads, it is well to hold the material up to the light, in order to see if there are any uneven places in the weave. These irregularities may be due to variations in the size of the yarns, or to irregular working of the take-up of the loom. Therefore, as with the warp, it is well to count the picks per inch in several places before taking an average.

The number of yarns in the space shown by the glass should be counted and multiplied by four. For instance, a piece of organdie may show twenty-four warp and twenty filling threads. Since the pick glass has a one-fourth inch opening, the warp per inch would be $24 \times 4 = 96$, and the filling per inch would be $20 \times 4 = 80$.

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PART III

FABRICS

CHAPTER XV

HISTORICAL DEVELOPMENT OF FABRICS

The earliest beginnings of the textile arts are prehistoric. As man first began to emerge from a state more animal than human, he felt a need for something more than food and shelter, so he began to devise crude implements for making materials from the grasses, reeds, and other plants which nature provided.

Tapa cloth. At first, clothing merely fulfilled a need for body covering, and tapa cloth or other very coarse materials were used in warm climates. The tapa cloth was made from the inner lacy bark of certain species of the mulberry tree. Layers of this bark were laid one on top of the other, as fibers of wool or hair are placed for felt. This mass was pounded together until it was as thick and as wide as desired. This made a material somewhat resembling paper, but very much stronger. In cold climates the skins of animals were utilized.

Wattling. As population increased, a desire for personal adornment brought about the decorating of fabrics. In all probability the wattling and weaving of baskets preceded the weaving of cloth. The principles of all weaving, from the most primitive to that done by the present complicated power machines, have been the same. There must be some means for forming a shed, through which a shuttle, holding the filling thread, can be thrown, and for battening or pushing up the filling threads to make the woven cloth firm.

Vertical loom. This loom was first used by the early Egyptians and is still used by our own Navajo Indians. The warp

threads are stretched between two heavy bars and suspended in a framework or from a branch of a tree.

Horizontal loom. The most primitive type of horizontal loom was placed on the ground. The warp was stretched between two beams and the weaver walked back and forth, picking the alternate threads as she inserted the filling. Later this was placed in a frame. The first improvement used with the

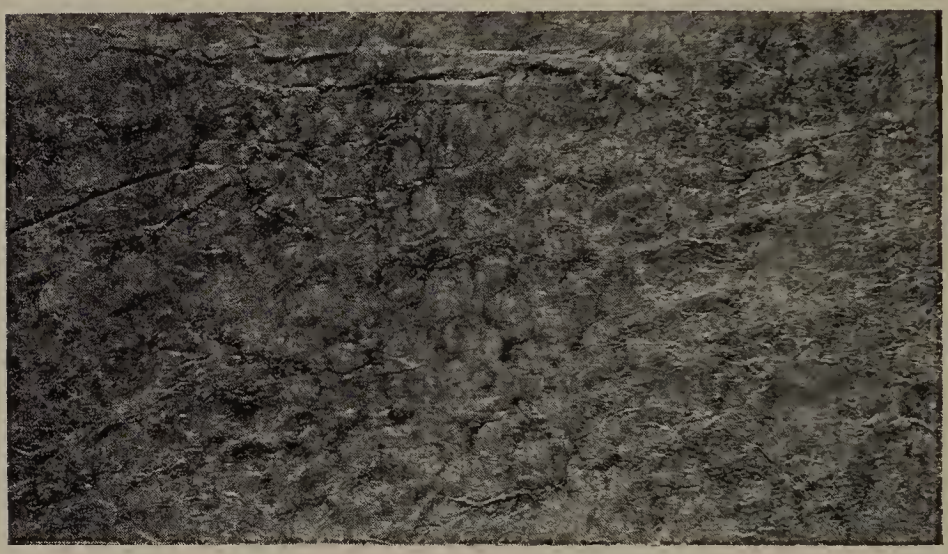


FIG. 24
TAPA CLOTH

loom was a heddle or held shaft. This held shaft consisted of a flat piece of board so cut that there was a series of slats, with spaces between, and a hole in the center of each slat. With this, it was possible to form a shed through which the filling thread could be thrown without the picking of the alternate threads. The warp threads were passed alternately between the slits and through the holes. A shuttle used with the heddle held the bobbin on which the filling thread was wound. The shuttle was pushed back and forth through the shed formed by raising

the heddle. A batten or rough comb was also used to draw up the filling threads, making the cloth firmer.

Colonial hand-loom. This loom was developed from the horizontal loom. It consisted of a framework with a large beam at the back, called the *warp beam,* on which the warp threads were wound. Two harness frames were suspended by cords from a beam in the center of the frame and connected by cords with the treadles underneath. These frames contained heddles, either of wires or cords, each having an eye in the center, through which the alternate threads passed. When raised or lowered by the treadles, a shed was formed through which the shuttle was thrown. In front of the harness frames was a batten, containing a reed which battened or pushed the filling threads together. This was called the *sley.*

Figure loom. As it was not possible to weave figures on a two-harness loom, the next invention was a loom having four or more harness frames. This made possible the weaving of simple designs in cloth. This was improved later by the invention of a fly shuttle by John Kay in 1733. This was a device by which the shuttle was thrown through the shed by a mechanical means instead of by hand. In 1760 Robert Kay, a son of John Kay, invented a drop box, which held several shuttles, each with a thread of a different color.

Draw loom. The earliest type of loom for elaborate figure weaving was the draw loom, which is still used in China. It is thought that this loom was first introduced into Europe from Damascus by the Crusaders; and hence the derivation of the word *damasks.*

Draw-boy loom. An improvement over this crude draw loom was the draw-boy loom. This made possible the weaving of figures facilitated by the use of cards on which the pattern was perforated. This loom was invented by Bouchon in 1725,

improved by Falcon in 1728, and again improved by Vaucanson in 1746.

Jacquard loom. In 1804 J. M. Jacquard invented the loom which bears his name, using the principles of the draw-boy loom. The raising and the lowering of the warp threads was controlled by a set of perforated cards, made for each particular design to be woven. The modern Jacquard loom is the same in principle.

Power loom. This loom, invented in 1775 by Dr. Edmund Cartwright, a clergyman of the Church of England, was a very heavy automatic loom which was improved upon by Roberts in 1830. It was modeled after the Colonial hand-loom, having a frame of cast-iron instead of wood, but most of the working parts were the same. It was operated at first by water power or steam, but at the present time is run by electricity.

Woven fabrics. The oldest fabrics in existence are those linens which have been found on the mummies taken from the tombs of ancient Egypt. Most of these linens are very fine in texture and without pattern. A few examples of tapestry fabrics have been found, however, which date back to the eighteenth dynasty, 1500-1400 B. C. Herodotus wrote, "The Egyptians wear a linen tunic fringed about their legs, called *calasure,* over which they wear a white woolen garment. Nothing of wool, however, is taken into the temple or buried with them, as their religion forbids it."

Some of the other early fabrics are:

a. Coptics. Materials of a tapestry weave in a mixture of linen and wool, very beautiful in design, have been found, belonging to the Coptic period, 370-700 A. D. These fabrics were woven by the Copts, lineal descendants of the Egyptians, who wove garments and other textiles for their Greek, Roman, and Mohammedan rulers. The designs were very different from those of the early Egyptian weaving.

b. Peruvian. The Peruvians carried the textile art to a high degree of perfection, but at a much later date (1300 A. D.).

FIG. 25
MODERN SILK, SHOWING ADAPTATION OF OLD COPTIC DESIGN

Peruvian cloth was very similar in weave and texture to the early Egyptian fabrics, but differed in design.

c. Indian. Beautiful cotton fabrics were woven in India at an early date. India had reached a high degree of civilization before the invasion of Alexander the Great (327 B. C.). The

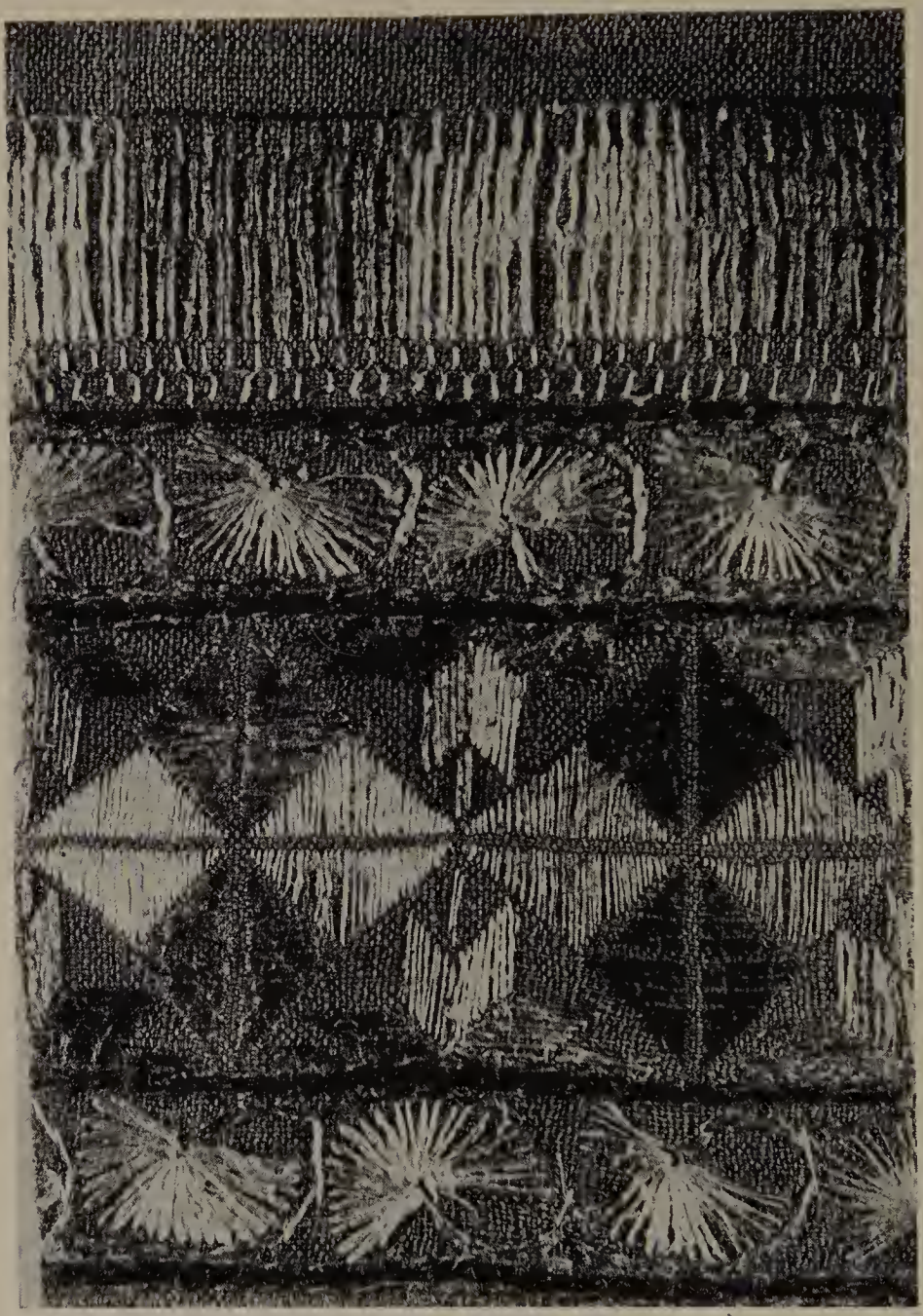


FIG. 26

SILK EMBROIDERY ON COTTON: OLD INDIAN

Persian influence was brought out in the design and color of the woven fabrics. It was further developed by commercial intercourse between Persia and India in the eighth century of

FIG. 27
EAST INDIAN HAND-BLOCKED PRINT

the Christian era. The highest development was reached under the Mogul dynasty in 1525, when very beautiful cotton brocades interwoven with gold and silver were produced. India was also famous for her cashmere shawls, which were very beautiful in color and design. The hand-blocked prints of the

eighteenth century were also very famous, as they are at the present time.

d. Chinese and Japanese. The history of the art of weaving in China is lost in antiquity; undoubtedly, however, the characteristics of the modern Chinese textiles are derived from

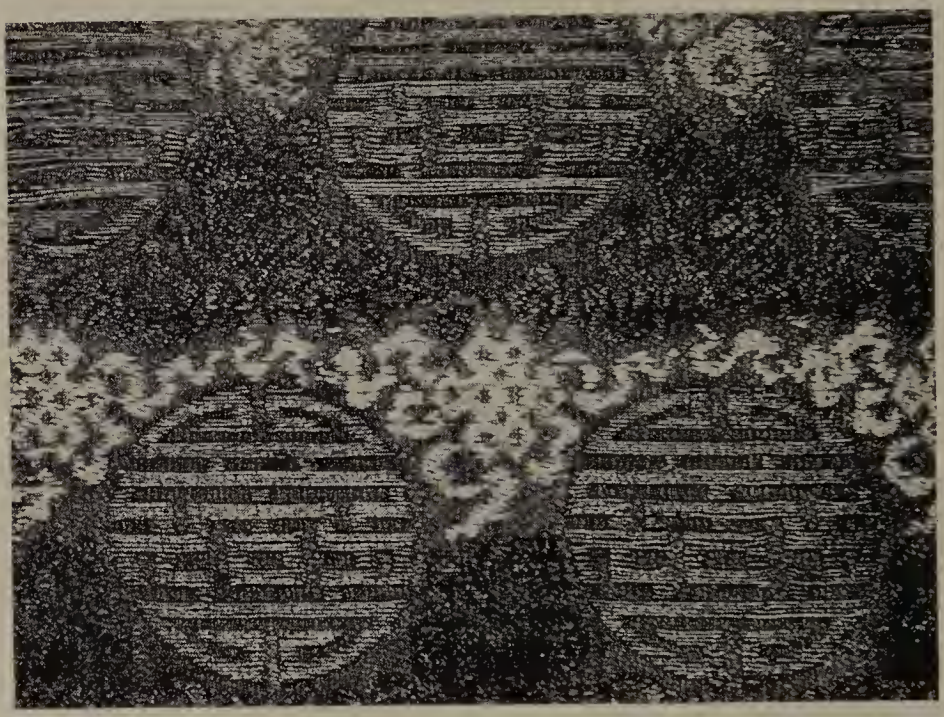


FIG. 28

CHINESE BROCADE: OLD MING DYNASTY

the ancient fabrics. Beautiful brocades, richly woven in gold and silver, were made in the Sung Dynasty from 960-1279 A. D. The principal emblems used were floral designs, the dragon, and wild geese. Silk culture in China dates back as early as 780 B. C. The textile arts of ancient and medieval Japan were undoubtedly derived from China.

e. Persian. The art in Persia reached its height in the latter part of the sixteenth century, as shown by the beautiful rugs,

brocades, and velvets of that era, all having distinctive qualities of technique, design, and color. The woven patterns of

FIG. 29
JAPANESE BROCADE

Persia have probably had a more lasting influence upon European fabrics than those of China or India, as shown in old fabrics found in our museums.

f. Italian. During the Mohammedan rule, 827 A. D., the art of pattern weaving reached its highest attainment in Sicily. There were exquisite silk brocades, bearing designs of animals,

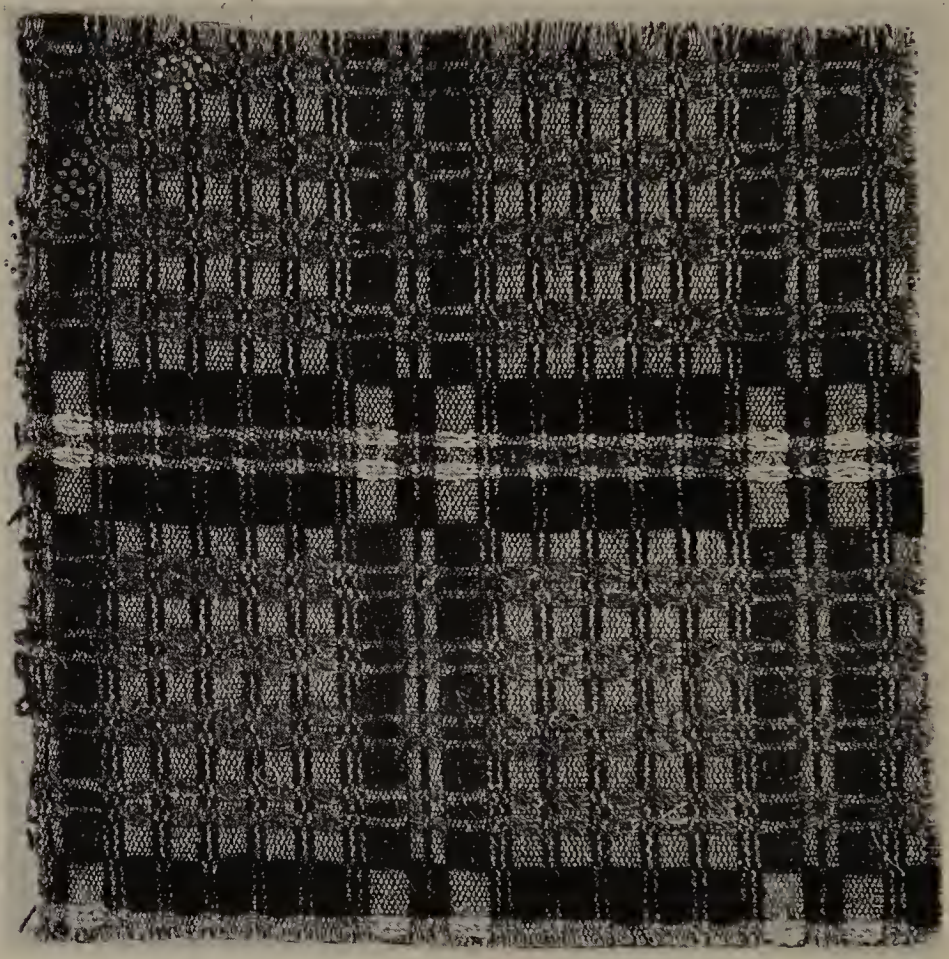


FIG. 30
HAND-LOOM WEAVING, EARLY AMERICAN TYPE

birds, and foliage, with inscriptions from the Koran or the names of princes interwoven. The early Italian brocades, damasks, and velvets of the fifteenth and sixteenth centuries were very beautiful, particularly the Florentine velvets, which

had the artichoke for their principal motif. The Venetian brocades were also lovely in texture and design.

g. French. In France, the manufacture of woven silk fabrics was introduced at Tours, in the latter part of the fifteenth century. During the seventeenth century the art reached its height, with Lyons as its center. The designs were either floral or conventional in character. The industry at Lyons suffered during the French Revolution and from that time on there was a decline in the character of the design.

h. Flemish. During the fifteenth and sixteenth centuries, the Flemish weavers were famous for their velvets and linen damasks.

i. English. The English weavers of the eighteenth century were noted for their brocades. The designs were small, dainty, and more naturalistic than those of the French and Italian brocades. The English were also noted for their chintzes of this century. These had all-over dainty designs, usually floral, which were suggested by the Chinese and Indian block prints.

j. Early American. During the colonial period, American-made fabrics were confined principally to homespuns of wool and linen and wool coverlets of interesting pattern. From 1760 to 1770 there were many machines invented for the spinning of yarns and the weaving of cloth in England, but the exportation of any of these machines was prohibited by legislation. Therefore, the manufacture of textiles by machinery was not accomplished to any great extent until after the Revolutionary War.

Knitted fabrics. Knitting was originally done by hand, but it is not one of the ancient arts. The first knitting frame was invented by William Lee, a curate of Calverton, England, in 1589. The knitting of hosiery on this type of frame had become a thriving industry in England prior to the American Revolution. The first circular knitting frame was invented by

Decroix in 1789. At first, knitting was used only for hosiery. With the realization that a knitted fabric was more desirable than a woven fabric for clothing worn next to the body, knitted underwear was introduced. Quite recently, knitted dress fabrics of both wool and silk have become popular. The most recent development is the Jacquard knitting frame, on which it is possible to knit figured materials. This is accomplished by a Jacquard attachment on the frame. The cards are placed below instead of above the knitting apparatus.

Laces. Specimens of the earliest laces, found in old Roman and Egyptian tombs, have been either cut-work, drawn-work, or work having the design darned in. In all probability, the earliest laces were needle-point, made almost entirely by the nuns and used almost exclusively for the church. Later, however, they were made by the ladies of the nobility, and the art gradually spread throughout Europe, until all classes of people were finally engaged in it. Laces may be divided into (*a*) needle-point, (*b*) bobbin, and (*c*) machine-made laces.

a. Needle-point. Needle-point or point-lace is made by hand with a needle. Patterns for needle-point were published about 1550.

b. Bobbin laces. The first bobbin lace was made in 1561, in Annaberg, Saxony, by Barbara Uttman, who established a school to teach peasant women. The lace industry was probably at its height about the middle of the seventeenth century.

c. Machine-made laces. The first machine lace was made by Hammond, in Nottingham, England, on his stocking frame. He copied the pattern in a cap belonging to his wife. The first machine on which it was possible to make the twist of transverse threads, forming a mesh, which resembled the hexagonal mesh made with bobbins, was invented by John Heathcoat of Leicester, England. This machine was improved upon by John Leavers of Nottingham, in 1813. The nets made on this

machine were beautiful and excellent imitations of the hand-made laces.

Felt. It is thought that the wearing of the skins of animals, with the fur next to the body, gave primitive man the idea of making cloth from the fibers of wool and hair. As the fibers were matted together by the heat and moisture of the body, man conceived the idea of placing fibers of wool or hair on top of each other in sheets and then felting them by heat and moisture into a fabric.

CHAPTER XVI

KINDS OF FABRICS

There are four kinds of fabrics: the woven, the knitted, the netted, and the felted.

WOVEN FABRICS

Woven fabrics are produced by interlacing two sets of threads, the warp and the filling, or weft, threads. The following classification of weaves is based on Barker's, and has three divisions: the straight thread, the curved thread, and the pile fabrics.

Straight thread fabrics. These fabrics comprise the plain, twill, figure, lappet, swivel, and double-cloth weaves.

a. The plain weave. The plain or tabby weave is the interlacing of the warp and filling threads at right angles. This makes a firm cloth, which wears well, but is not so attractive as some of the more elaborate weaves. It has the following variations:

1. The basket weave: This is produced by the regular interlacing of two or more warp threads with a group of two or more filling threads. It is usually a loose, heavy weave; it therefore pulls and stretches easily.

2. The rib weaves: There are two rib weaves: the rib in warp direction, and the rib in weft direction. The former has a lengthwise cord formed by having a group of warp threads through each heddle; the latter has a crosswise cord formed by a group of filling threads woven in each shed.

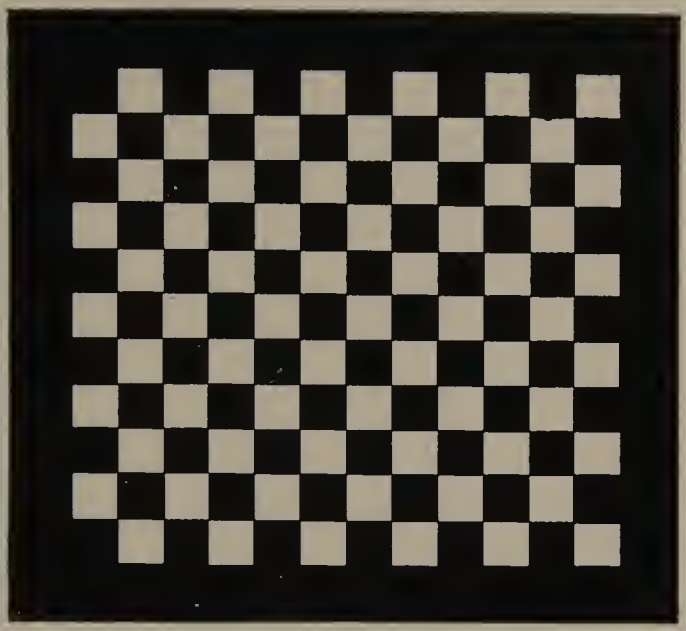


FIG. 31
PLAIN
WEAVE

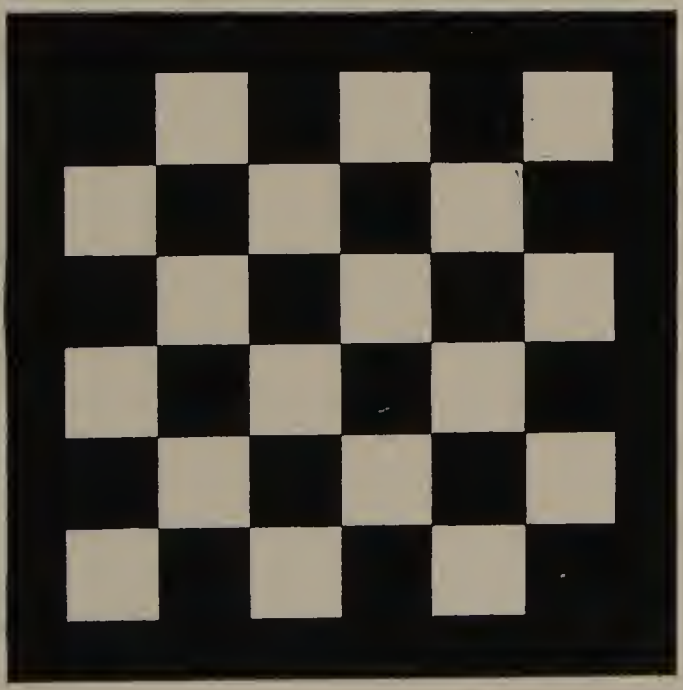


FIG. 32
VARIATION OF PLAIN WEAVE: BASKET WEAVE

Some materials have a combination of occasional ribs in both warp and weft directions forming checks or crossbars. In materials having heavy ribs, there is a tendency for the finer threads to pull away from the rib.

3. Crêpe cloths: These cloths are produced by several different methods. They may be produced by twisting the filling

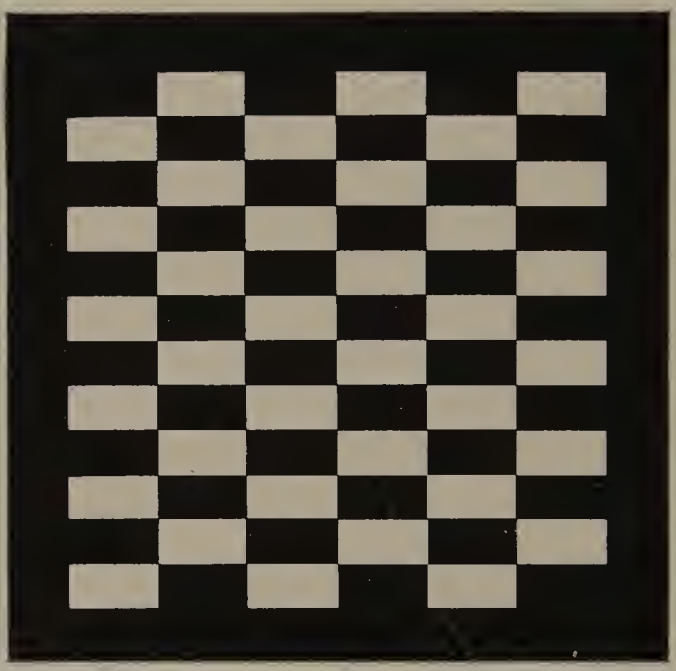


FIG. 33
VARIATION OF PLAIN WEAVE: RIB IN WARP DIRECTION

threads tighter than the warp threads. The number of twists varies according to the amount of contraction necessary to give the desired crêpe effect. If a very decided crêpe effect is desired, in the georgettes for instance, both the warp and the filling threads are very tightly twisted. Often a crêpe effect is produced by embossing or by chemical shrinkage. This is a much cheaper method, but it is not permanent. The rayons are

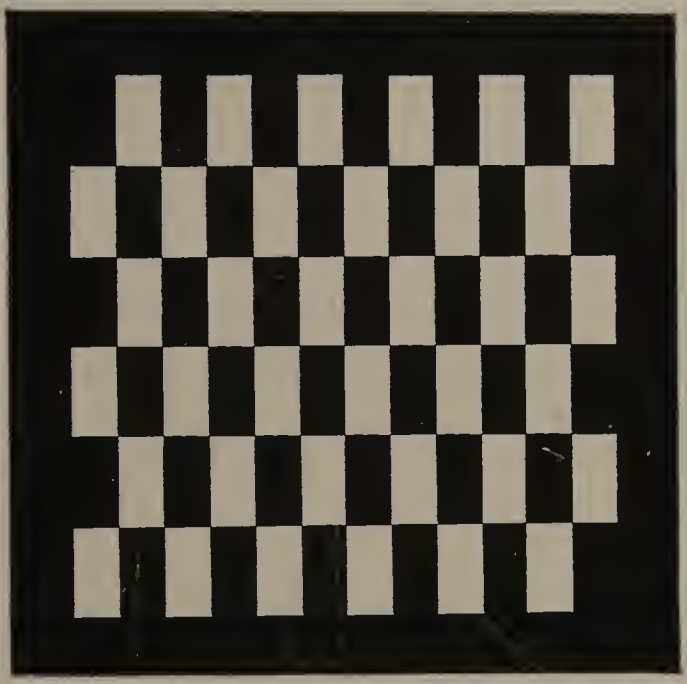


FIG. 34
VARIATION OF PLAIN WEAVE: RIB IN WEFT DIRECTION

FIG. 35
TWILL WEAVE

crêped by treating the filling threads of rayon with caustic soda, which crinkles the yarn.

b. Twill weave. The standard twill is produced by the interlacing of the warp and the filling threads, so that the floats are grouped in diagonal lines. The appearance of the

FIG. 36
VARIATION OF TWILL WEAVE: HERRINGBONE TWILL

twill depends on the amount of twist in both warp and filling. Twills vary, depending upon the number of shafts used to complete the pattern: there may be from three to forty or fifty; as a result, the possibilities of design are numerous. The twill weave wears better than most of the other weaves, as it is usually firmer and more closely woven. The following variations are the most common: (1) the rib, (2) the corkscrew,

(3) the double, and (4) the herringbone twills; and (5) the satin and sateen weaves.

1. The rib twill: This is a heavy diagonal rib. The twill effect is more pronounced if the twill is in the same direction as the twist of the yarn.

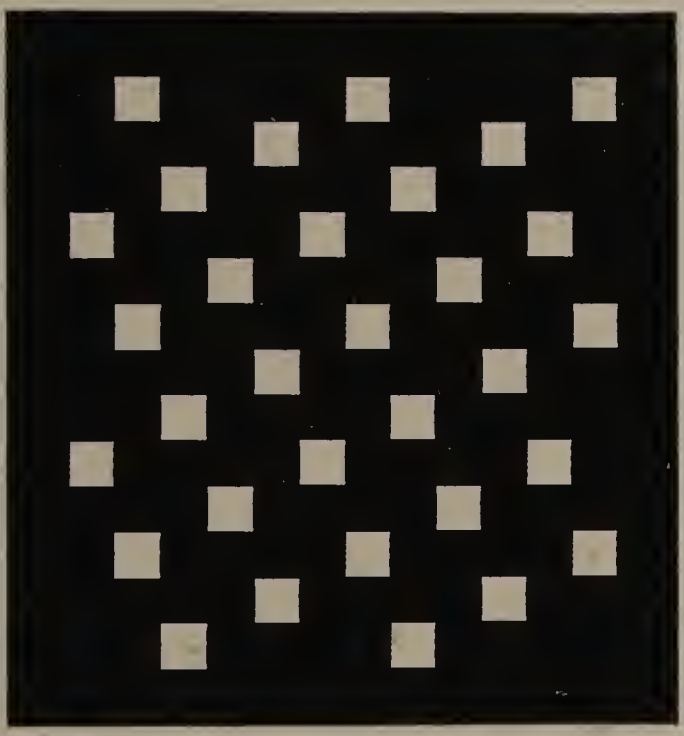


FIG. 37
VARIATION OF TWILL WEAVE: SATEEN WEAVE

2. The corkscrew twill: This twill is similar to the rib twill, but there are spaces between the twills.

3. The double twill: This is a group of two rib twills, having a space between the groups. This gives the appearance of their having been knit.

4. The herringbone twill: The twill is obtained by varying the point of commencement and reversing the twill. This gives the effect of the backbone of a fish.

5. Satin and sateen weaves: These are special forms of the twill. There is a broken diagonal rather than a true diagonal, and there is no trace of the twill on the surface of the cloth. In satin, the warp is thrown to the face of the cloth; whereas in sateen, the filling is thrown to the face. Yarns of loosely

FIG. 38
VARIATION OF TWILL WEAVE: SATIN WEAVE

woven satins or sateens often pull or rough up because of the long floats on the surface. The shorter the float, the better the material.

c. Figure weave. The most elaborate figure weaves are produced on the Jacquard loom. Each warp thread is so controlled that it is raised or lowered according to the design worked out on the cards. A series of hooks connects with the

heddles on the loom and is raised by a series of horizontal needles. The number of hooks and needles depends upon the size of the loom and varies from 200 to several thousand.

These needles are attached at right angles, according to a perforated pattern on a card. When the needles are pressed

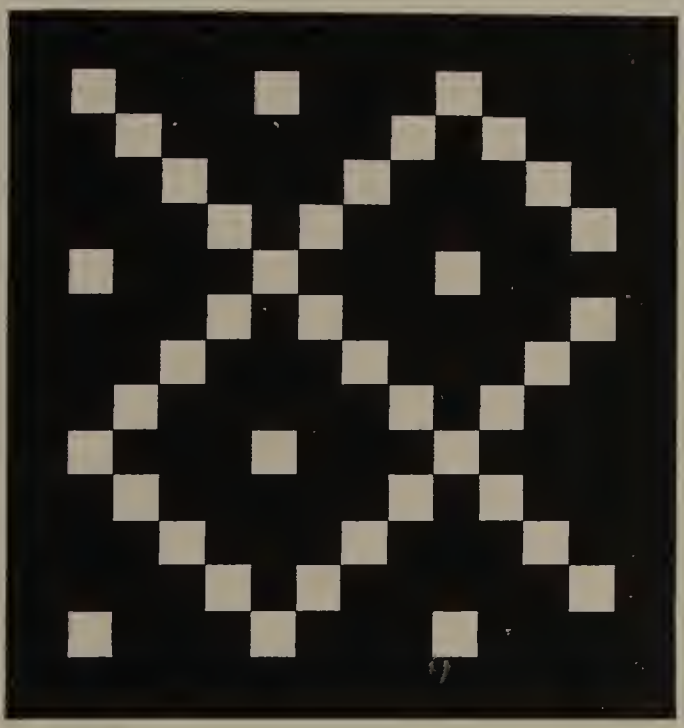


FIG. 39
FIGURE WEAVE: BIRD'S-EYE

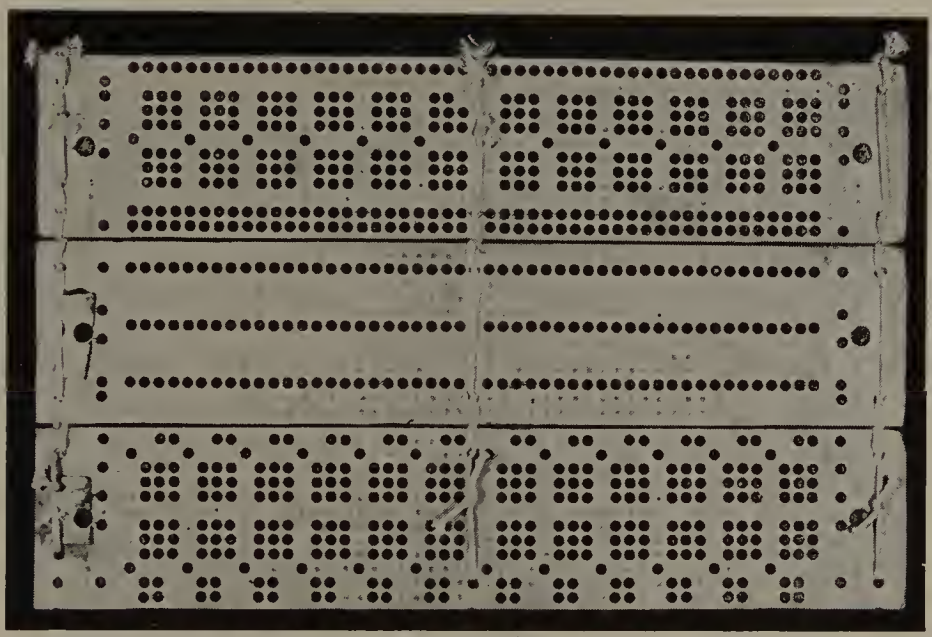
back by the card, the hooks are carried beyond the griff. The griff is an arrangement of parallel bars which lifts the heddles. The card passes over the cylinder and presses against the heddles. As the needles are pushed back by the blank spaces between the perforations on the card, the griff is raised. This process carries the hooks and the leash cord with the warp threads. As the cylinder revolves, the needles return to their normal position.

The process is very expensive, as the cards are made on a special machine. The design is worked out on point paper. A series of dots is printed on the cards and these dots are then

FIG. 40
FIGURE WEAVE: JACQUARD

punched. Each card contains one pick of the design. Each card is numbered, and the cards are laced together and hung over a cylinder in the loom. The number of cards depends upon the design. A very elaborate design would take thousands of cards.

d. The lappet weave. This weave has the effect of hand embroidery introduced into either a plain or gauze weave. It is produced by a lappet attachment on the loom. The figures or dots are embroidered on the material after it is woven and the threads left between the figures or dots, on the wrong side of the cloth, are cut.



Courtesy of Mr. Beveridge Dunlop, Vice-President of American Glanzstoff Corporation of New York.

FIG. 41

JACQUARD CARDS

e. The swivel weave. This is made with tiny shuttles, carrying extra weft threads, which weave the figure. The wrong side of the material shows the cut ends. There is a tendency for the threads forming the design to pull out.

f. Double-cloth weave. This is a cloth having a double warp and filling. Two of these cloths may be interlaced at intervals and made into reversible materials, such as those used in heavy coatings and blanket cloth. The chief advantage of

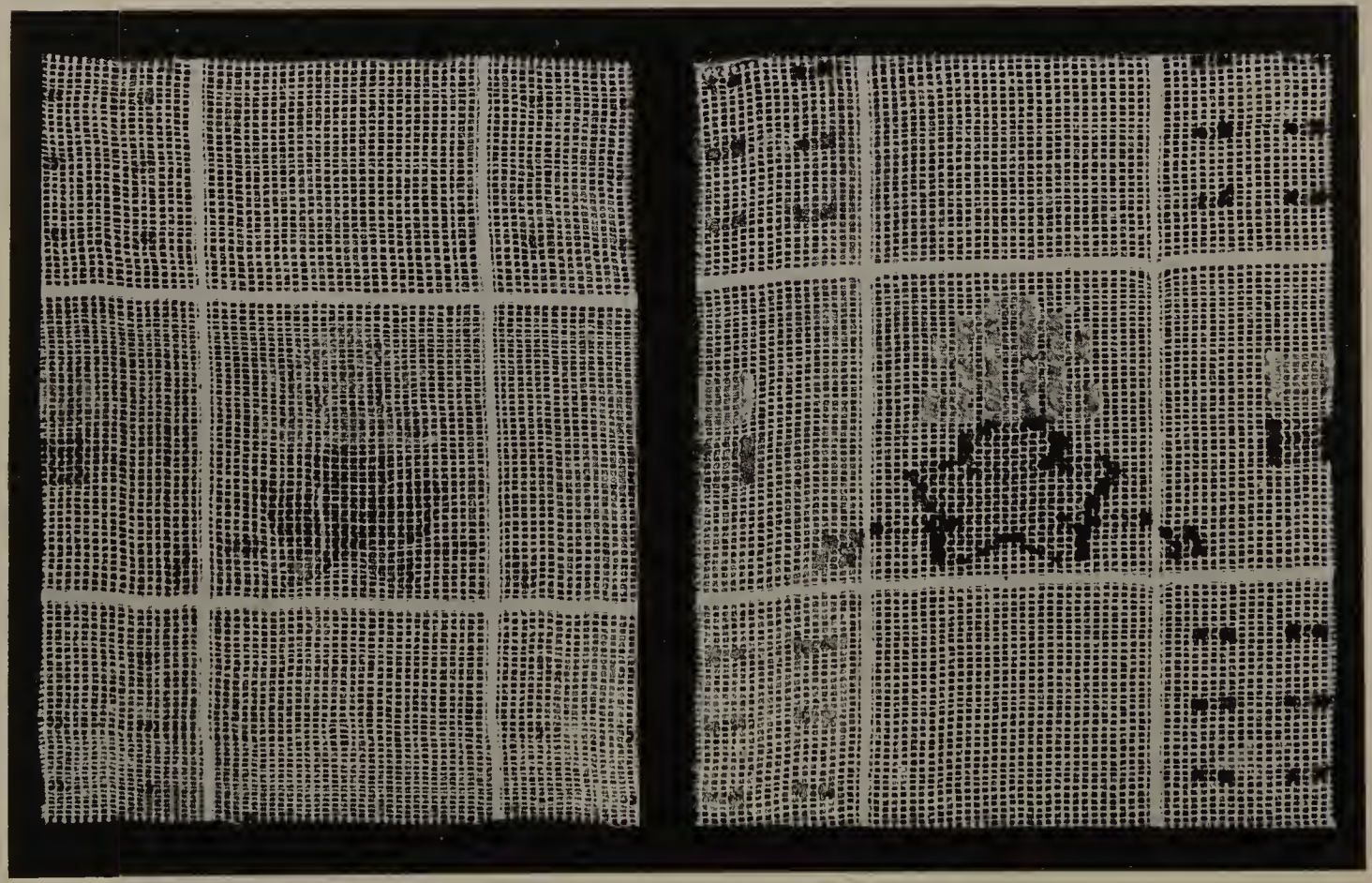


FIG. 42

SWIVEL WEAVE

Left, right side; right, wrong side.

this kind of material is its warmth. The tubular materials, used for pillow cases, bags, and knit goods, are sometimes called double-cloth materials.

Curved thread fabrics. This group includes the gauze and leno weaves.

a. Gauze weave. For the gauze weave, two warp threads are twisted together in such a way that the filling may be passed

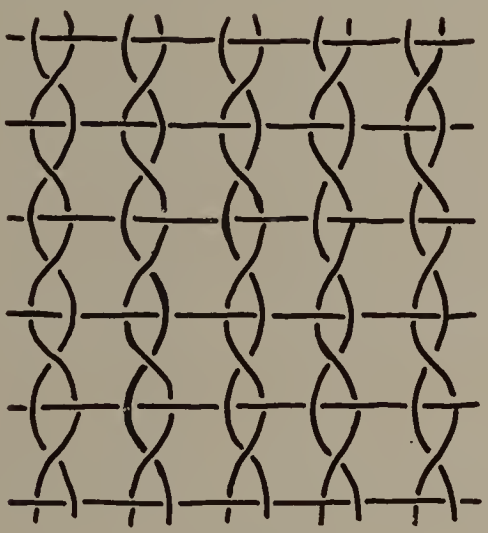


FIG. 43
GAUZE WEAVE

through. The filling threads are not so easily pulled out as they are in a plain woven fabric. Marquisette is an example of the gauze weave.

b. Leno weave. This is a combination of the gauze weave with some other weave. Often it consists of a stripe or figure in the gauze weave on a plain ground.

Pile fabrics. A cloth having the threads standing close together on the surface is called a *pile fabric*. The depth of the pile varies in different materials. There are two kinds of pile fabrics, the cut and the uncut. The cut pile is made by

weaving a double cloth with the threads from each interlaced. This fabric is slit through the center by a knife, which forms two pieces of cloth with a pile on one side of each piece. Velvets, velours, and plushes are woven in this way. The corduroys are so woven that a rib is formed. The uncut pile fabrics are made with two sets of warp threads, one of which is held loosely to form the loops, and the other held tight. Several filling threads are inserted before they are battened. This weave is used for Turkish toweling and terry cloth.

KNITTED FABRICS

Knitting is a method of constructing cloth by the interlooping or interlocking of the yarn with needles, either by hand or by machine. There are three classes of knit goods: the weft-knit, the warp-knit, and the figure-knit.

Weft-knit. In the weft-knit, each row of loops is supported by the next row. They may be knit in a flat piece on a flat machine or knit in a tubular piece on circular machines. The three most common kinds of weft-knit goods are the plain, the rib, and the purl. The plain knit is formed by the interlooping of one or more weft threads. They may be either flat or tubular. The rib-knit is formed by ridges connected on one side of the cloth with the next group on the reverse side. This produces a fabric which is very elastic and therefore desirable for underwear. The purl-knit is produced by connecting one row of loops on one side of the cloth and the next row on the other side. In principle the purl-knit is the same as the plain knit without reversing.

Warp-knit. The most common types of warp-knit fabrics are the tricot warp, which resembles the weft-knit, and the vertical stripe, which produces a vertical stripe effect. These are usually piece-goods.

Figure-knit. Figure-knit fabrics are produced on a knitting frame which has a Jacquard attachment, on which it is possible to make fabrics with elaborate patterns.

Hosiery manufacture. There are two kinds of hosiery: (*a*) that made from circular goods, and (*b*) the full-fashioned.

a. The circular. There are two kinds of circular goods. Both are made from round tubing and are knitted on circular machines. One, the seamless, produces the entire length of the stocking without a seam. The toe-piece is attached by a loop attachment. This is the cheapest kind, and the stocking is ill-shaped, because it does not fit the foot or the ankle. The other has a mock seam; the tubing is cut, and the leg is shaped by cutting out a sufficient amount from the calf of the leg to the heel. The whole length is then seamed from the heel up and mock fashion-marks appear on either side of the seam, at the calf of the leg. This kind of circular hosiery is much better shaped than the seamless.

b. The full-fashioned. This is the best grade of stocking on the market. They are knit in flat strips. This is an expensive process, as it is produced on specially constructed machines which automatically drop the required number of stitches at the ankle and the toe; the heel and gusset are shaped in the same way. After the stockings are taken from the knitting frames, they are scoured, shaped on forming boards, and pressed.

Manufacture of underwear. Underwear, like hosiery, is made either seamless or full-fashioned. The seamless is made from a knitted web, which is made in a roll, finished, and cut. The full-fashioned is shaped when knit. There are several advantages of knit goods over woven for underwear. It is more hygienic, since its porosity enables it to absorb perspiration more readily than a woven fabric. It is more elastic; therefore it stretches and fits the body better. It is cheaper than the

woven, as it does not require as skilled labor as weaving, thereby making the cost of production less.

Circular knitting machines. There are two principal kinds of circular knitting machines, (*a*) the latch needle and (*b*) the spring-needle. Both machines are circular. The needles are fastened to a cylinder, which may be anywhere from fifteen to twenty-four inches in diameter, depending on the width required. The size of the needle depends on the fineness or the coarseness of the fabric to be knit. In all machine knitting, there is a needle for every loop, and in most machines the needle slides back and forth in slots when forming the loop.

a. Latch needle. The latch needle has a straight shank, having a hook at one end with a latch which springs freely on a pin, lengthwise of the needle but not sidewise. As the needles move downward, the hooks catch the threads and the latch closes.

b. Spring needle. For fine materials the spring needle is used. It has a long shank with a fine hook, having one end pressed into a depression on the shank of the needle from which the finished loop slips off.

Kinds of knit underwear. There are four principal kinds of knit goods for underwear: (*a*) the flat-knit, (*b*) the rib-knit, (*c*) the fleece-lined, and (*d*) the mesh-knit.

a. The flat-knit shows the loops on the face of the material in wales or lengthwise rows, while the back shows courses or crosswise rows.

b. Rib-knit fabrics are knitted on either a latch needle or a spring-needle machine. To form the loops, they are drawn first to the face and then to the back of the fabric.

c. Fleece-lined fabrics are made of cotton, cotton-and-wool mixtures, or all wool. Three sets of yarn are used, a fine yarn for the face, a heavier yarn for the back, and a very fine yarn

to connect the two. By two small rollers, covered with wire teeth, the surface of the cloth is scratched so as to form a nap.

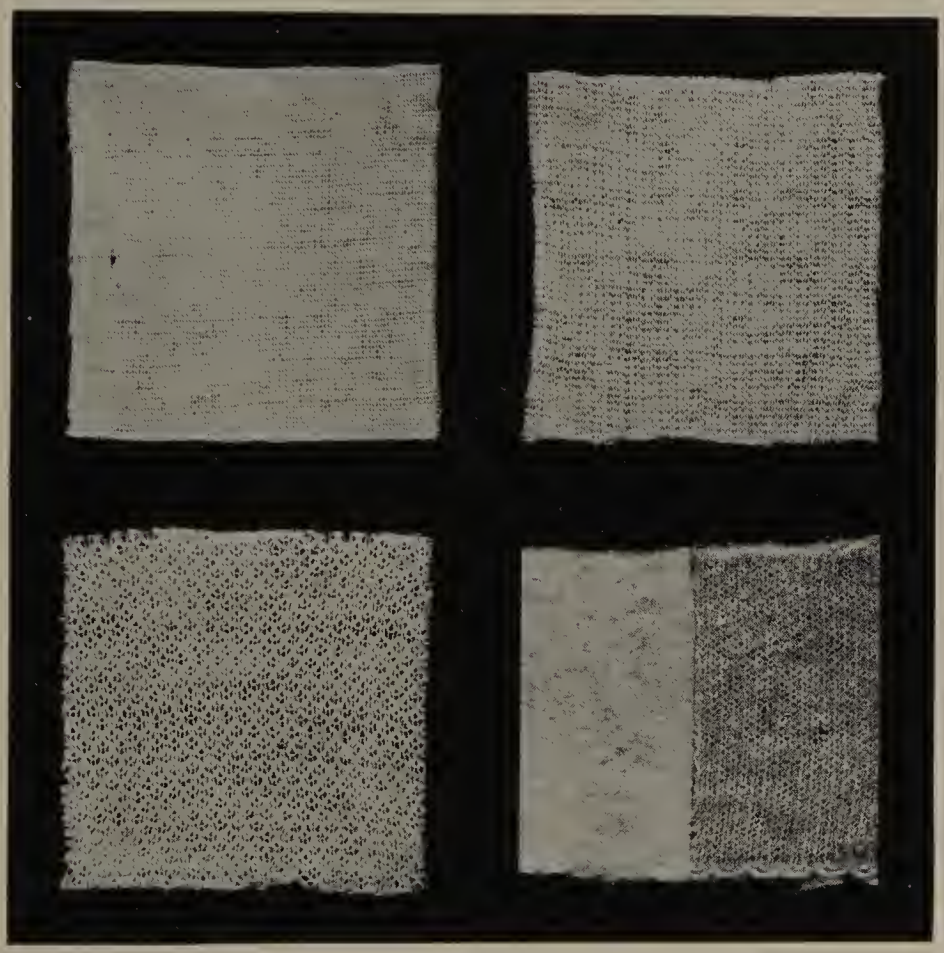


FIG. 44

KNIT GOODS USED FOR UNDERWEAR

Upper left, flat-knit or plain knit; upper right, rib-knit; lower right, fleece-lined; lower left, mesh-knit.

d. Mesh-knit fabrics are produced on machines similar to those used for flat knitting. In this way a honeycomb effect and an open mesh are produced. Because of the open spaces, this fabric is porous and therefore hygienic.

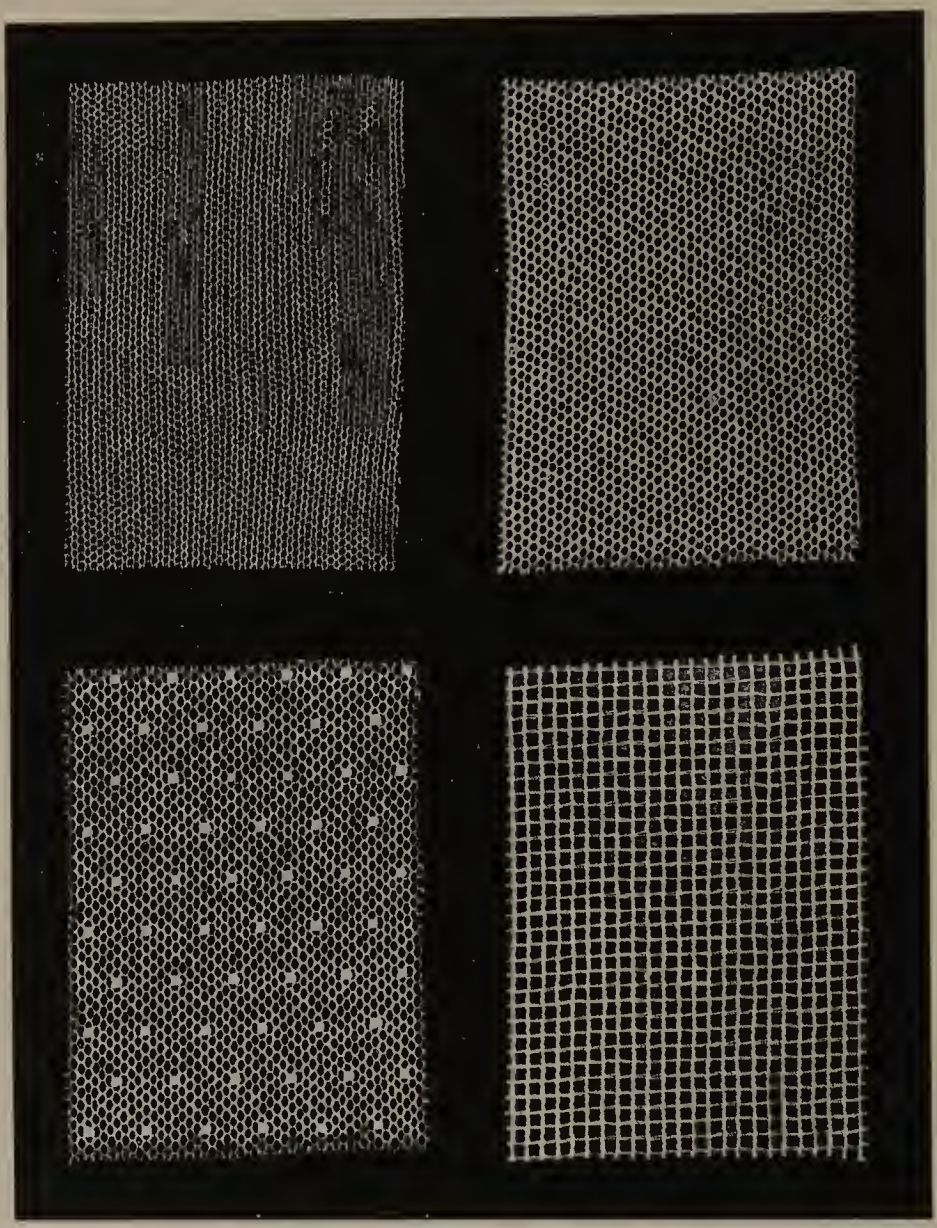


FIG. 45

NETTED FABRICS

Upper left, maline; upper right, bobbinet; lower left, point d'esprit; lower right, filet.

NETTED FABRICS

Nets and laces are produced by the interlooping or interlacing of threads in such a way that they will not ravel. The nets were originally made with a needle or bobbins, but now

FIG. 46
ALENÇON LACES
Upper, hand-made Alençon; lower, machine-made Alençon.

nearly all are machine-made. There are several different kinds of net. One kind, maline, is made of silk with a very fine mesh, and is very stiff. The best malines are chemically treated in order to make them withstand moisture. Tulle, another kind, is similar to maline, but has a softer finish. Bobbinet is a coarse net of silk or cotton, having the threads twisted to form

FIG. 47

POINT DE VENICE LACES

Upper and middle, hand-made point de Venice; lower, machine-made point de Venice.

a hexagonal mesh. Filet net has a square mesh and is an imitation of hand-made lace. Point d'esprit has a rather fine net ground with small square dots.

FIG. 48
PRINCESS LACES

Hand-made laces. There are three distinct classes of hand-made laces: (*a*) the needle-point, (*b*) the bobbin, and (*c*) crochet.

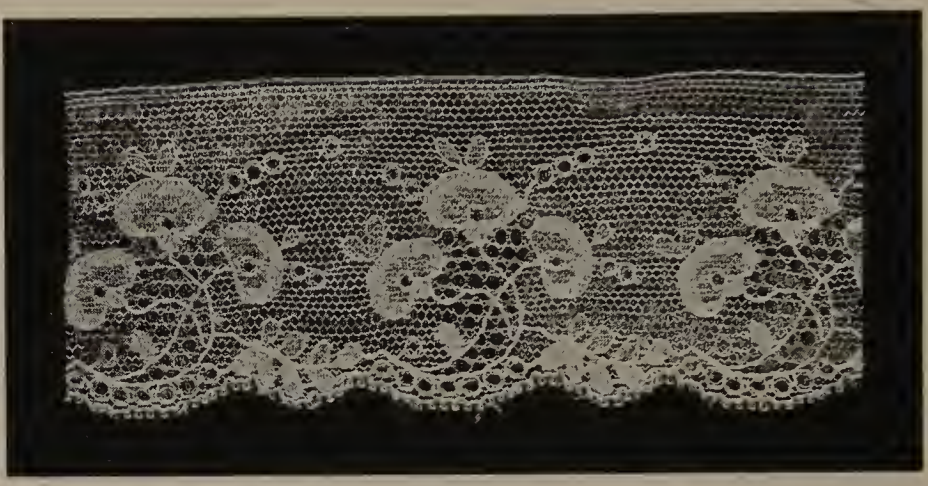


FIG. 49

MACHINE-MADE CHANTILLY

FIG. 50

DUCHESSE LACES

Upper, hand-made duchesse; lower, machine-made duchesse.

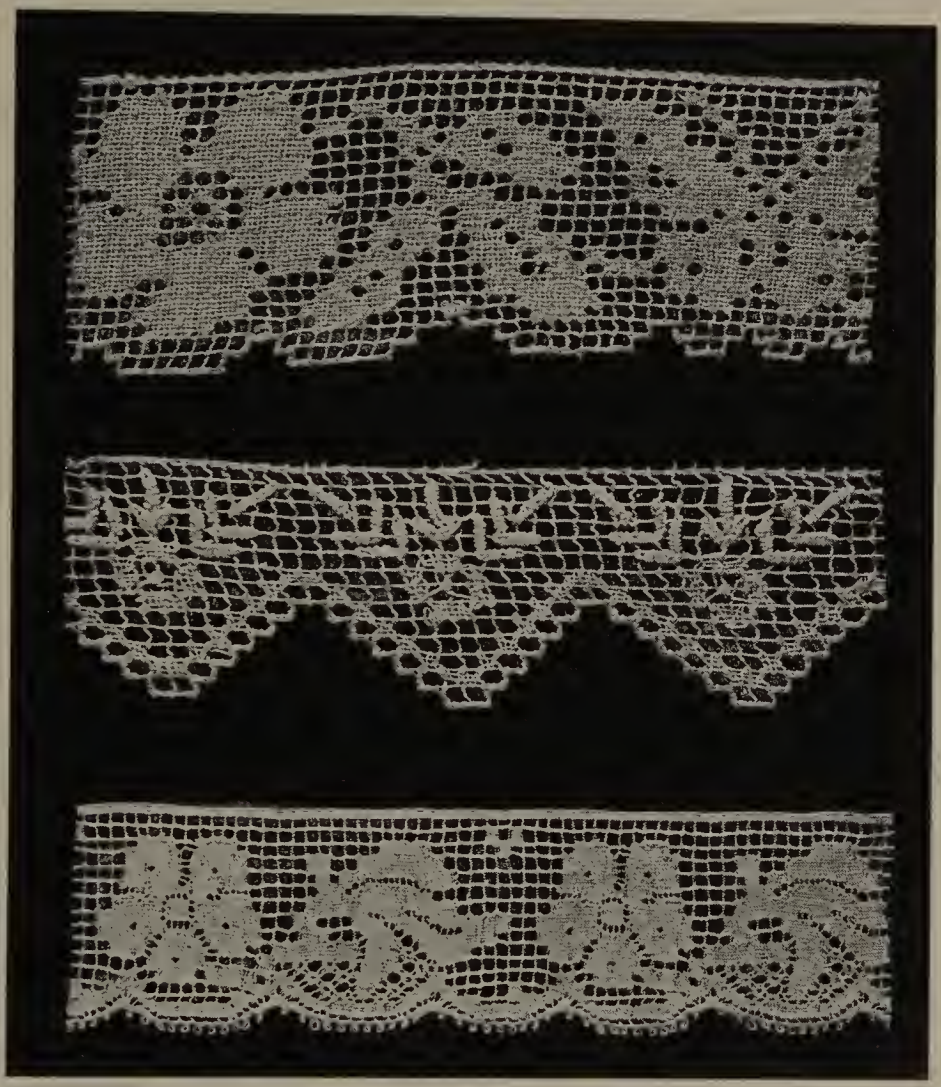


FIG. 51

FILET LACES

Upper, filet; middle, filet antique; lower, machine-made filet.

a. Needle-point. The designs of all needle-point laces are worked out on black paper, with tiny holes pricked in the paper. This pattern is sewed on a piece of double white cloth. The lace is made with a needle which follows the perforated pat-

FIG. 52

CLUNY LACES

Upper, Japanese Cluny; middle, Cluny; lower, machine-made Cluny.

tern. There are several well-known and widely used kinds of needle-point laces. The Alençon has a ground of several sizes and kinds of mesh with the figure or design outlined with a heavy cord. Point de Venice is a heavy lace with the floral or geometric designs made entirely with buttonhole stitches, the

FIG. 53
TORCHON LACES
Upper and middle, hand-made Bavarian torchon; lower, machine-made torchon.

motifs being connected with brides or bars and bearing occasional picots.

Tape or princess lace, the most common of all the needle-point laces, either has a design made of tape and held together with various kinds of stitches, or has a tape applied on net. The designs of tape lace are usually floral in pattern.

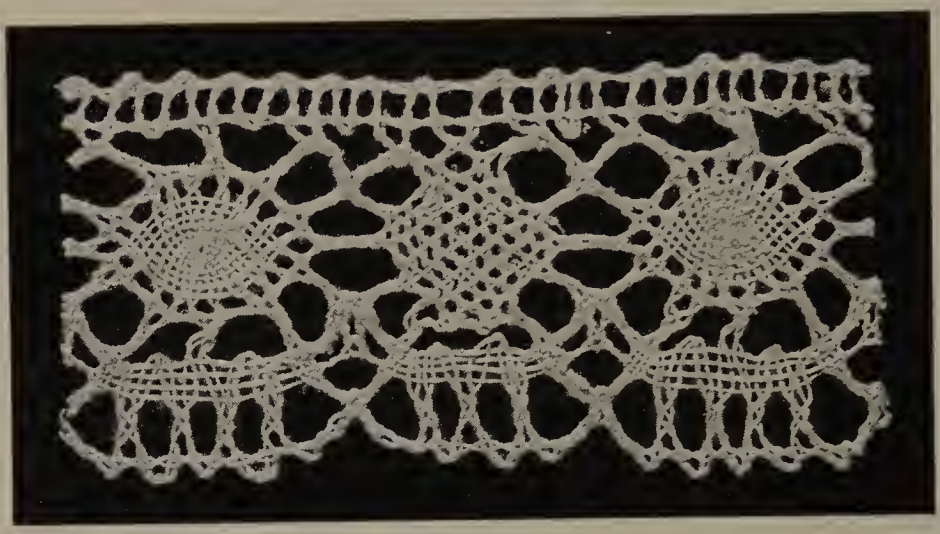


FIG. 54
MEDICI TORCHON

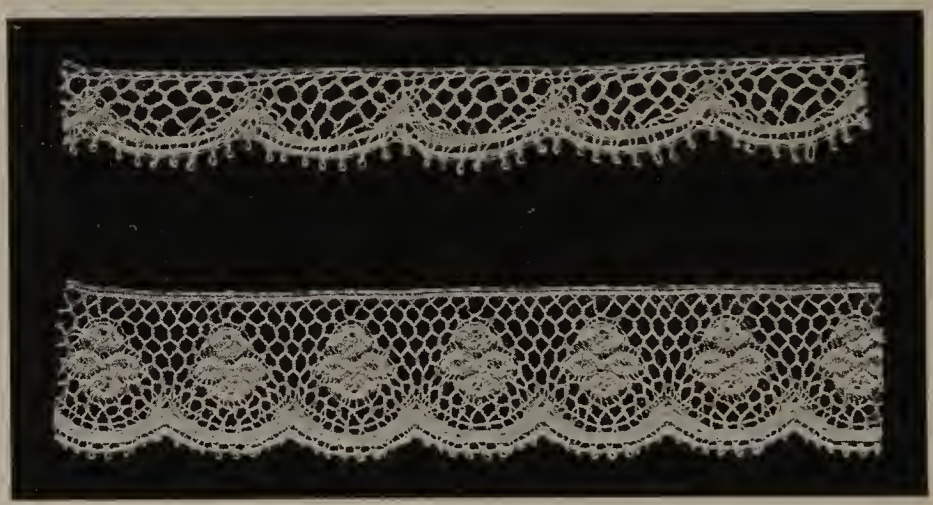


FIG. 55
GERMAN VALENCIENNES LACES
Upper, hand-made German Valenciennes; lower, machine-made German Valenciennes.

b. The bobbin laces. These laces are made with bobbins on pillows or cushions. A parchment design is placed on the cushion and held in place by pins. A number of bobbins carry the thread and are twisted in and out around the pins. Some patterns require as many as a thousand bobbins. The most common laces are as follows:

FIG. 56

ENGLISH VALENCIENNES LACES

Upper, hand-made English Valenciennes; lower, machine-made English Valenciennes.

1. Chantilly: This is a silk lace in which a heavy cord outlines the design. It is either a cream white or black, the white being called *blonde,* and the black, *black silk.* These laces were originally made by hand, in Chantilly, France, but now almost all of them are machine-made. The Spanish laces are quite similar.

2. Duchesse: This has a tape-like effect, obtained with

the bobbins, the motifs being connected with various stitches.

3. Filet: This rather coarse linen lace has an open square mesh with the design darned in on net. Filet antique has a raised design worked on the square mesh.

FIG. 57

FRENCH VALENCIENNES LACES

Upper, hand-made French Valenciennes; lower, machine-made French Valenciennes.

4. Cluny: This is a coarse linen lace, having a characteristic motif of leaves in groups of from two to twelve, on a torchon base. The Japanese Cluny has the same leaf-like design and a fan-shaped scallop. The real Cluny can be readily distinguished from the imitation by the irregular, loose weave of the leaves.

The imitation is much more compact and regular than the genuine.

5. Torchon: Of all the bobbin-made laces, torchon is the most common and least expensive. There are three kinds. The Bavarian, the cheapest and most common, is often called *beggar's lace.* The Medici, with closely woven motifs, usually in oblongs or squares or both, is very coarse. The Florentine,

FIG. 58

OLD FLANDERS LACES

Upper, hand-made Old Flanders; lower, machine-made Old Flanders.

the most beautiful of the torchons, is often mistaken for Cluny, as it is quite similar, but it does not have the characteristic leaf.

6. Valenciennes: These are narrow laces, having a very fine mesh and small, closely woven designs. The imitations are difficult to distinguish from the real. There are three kinds. The German, which is the coarsest, has a round mesh. The French, the finest, has a diamond-shaped mesh. The English is similar to the French, but is coarser.

7. Old Flanders lace: This is narrow lace having a hexagonal-shaped mesh, with small flat designs outlined with a cord.

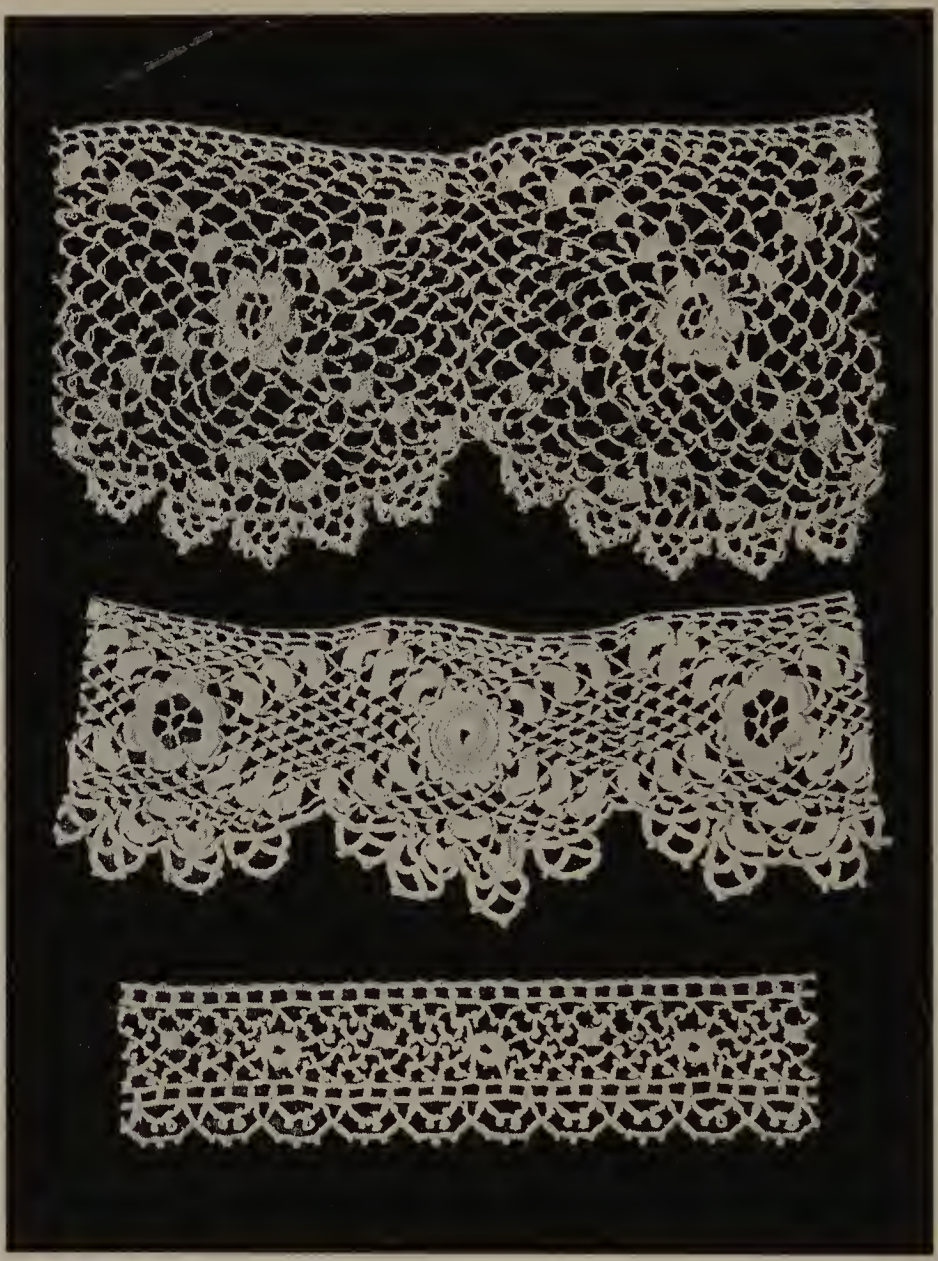


FIG. 59

CROCHET

Upper, Irish crochet; middle, Chinese crochet; lower, machine-made Irish crochet.

c. Crocheted laces. These laces are made by hand, with a hook. The Irish crochet is by far the most beautiful. It is loosely crocheted, and the motifs, the shamrock and the rose, are made separately and put together with brides and picots. The Chinese crochet, though much more common, is not so beautiful. It is more closely crocheted and much heavier than the Irish.

Machine-made laces. The threads of machine-made laces are stretched up and down on the machine in a way similar to that of the warp threads on a loom. Tiny bobbins, which carry the thread, pass between the warp threads in such a way that the threads from the bobbins twist around the warp threads, thus forming the pattern. The threads are then pressed together with combs.

FELTING

Felting is produced by the matting together of thoroughly mixed fibers of wool or hair. These fibers may be short-staple wool, shoddy, mill waste, or different grades of wool or hair. The processes are as follows: the fibers are blended by combining different grades of wool and hair; they are then carded as the fibers for woolen yarns are carded; the layers of carded wool are laid on top of each other, until the layer is as thick as desired; they are then pressed by hot, vibratory rollers, and felted with soap, water, heat, and pressure.

CHAPTER XVII

COLORING FABRICS

The earliest record of the use of dyestuffs, as found in ancient Chinese records, is 2600 B. C.

Color. From a physical standpoint, color exists only in light. Light is made up of different wave-lengths, and when light is passed through a glass prism, we see the colors of the rainbow, which are called *spectrum colors.* They are red, orange, yellow, green, blue, and violet. Black absorbs color; white reflects color. The three elements of color are: (1) hue, which is the color; (2) value, which is the amount of black or white, combined with the hue, the colors containing black being called *shades,* and those containing white, *tints;* and (3) chroma, which is the intensity of the color.

THE CLASSIFICATION OF DYESTUFFS

Dyes are classified as natural and artificial.

Natural dyes. These dyes have been used from early Biblical times to within the last sixty years. They are divided into three groups: the vegetable, the animal, and the mineral. The vegetable dyes include indigo, fustic, sumac, butternut, cutch, madder, henna, saffron, and logwood. The last, used to dye black silk, is the only one now employed to any great extent. There is only one animal dye, cochineal, which is made by grinding cochineal insects into a powder. The mineral dyes are Prussian blue, chrome-yellow, and iron buff.

Artificial dyes. These dyes, which are coal-tar products, were discovered in 1856 by William Henry Perkins, a boy

fifteen years of age. He was trying to prepare a synthetic quinine by isolating phenanthrene from coal-tar. In oxidizing the aniline oil, a thick mass was produced, which, when washed with alcohol, gave a beautiful purple or mauve-colored solution. Ten years later Perkins produced a synthetic alizarin. From this beginning, thousands of artificial colors have been developed. These colors are much more easily obtained and applied than the natural colors, and the color range is much greater. The following dyestuffs are those commonly used for dyeing textiles.

a. The acid dyes. These are the salts of color acids and are derived from azo compounds of benzene and toluene. They are the direct dyes for the animal fibers. They are cheap, easily applied, and fairly fast to light, but not so fast to washing.

b. The basic dyes. These are the salts of color bases and are derived from aniline. They are also direct dyes for the animal fibers. They give a more brilliant color than the acid dyes, but are not fast to light and have a tendency to bleed.

c. The substantive dyes. These are derived from benzidine and tolidine. They are also called the *direct cotton colors,* as they are the direct dyes for the vegetable fibers. They are, however, of a neutral chemical nature, as they will also dye the animal fibers. The colors are soft and more fast to light than those given by the basic dyes.

d. Mordant or adjective dyes. These dyes are mostly the alizarin colors and are derived from anthracene. They are also of a neutral chemical nature. They are not applied directly, but always through some other substance. This substance, called a *mordant,* combines with the dyestuff and forms an insoluble salt or a color lake. The alizarin colors are the principal colors used with a mordant. Mordants may be applied to the fiber before or after dyeing, or in the same bath, which is the cheapest method.

e. Sulphur dyes. These are derived from organic substances, by fusion with sodium sulphide and sulphur. They are used only for vegetable fibers.

f. Developing dyes. These consist of substances which are not fully brought out in tone until a developing process is used.

g. Vat dyes. These dyes, so called because they are rendered soluble by certain chemical reactions in large vats, are derived from anthracene and carbazol. They are direct for the vegetable fibers and are more fast to washing and light than any of the other dyes. After the fabric has been immersed in the dye bath, certain chemicals are added in order to fix the dye on the fiber.

THE APPLICATION OF DYES TO FABRICS

Dyes are applied to materials by dyeing or printing.

Dyeing. This is the process of immersing either the raw fibers, yarns, or fabrics in a liquid dye bath. When a material is made of both animal and vegetable fibers, for example a cotton warp and a wool filling, the cotton yarn may be dyed with a direct cotton dye. After it is woven with the wool, the cloth is dyed with a direct dye for wool. This is called *cross-dyeing.* Another method is to immerse the mixed cloth in two baths, one bath a direct dye for the vegetable fibers, the other for animal fibers.

Printing. The dyes are the same as those used for dyeing, except that they are applied in the form of a paste, instead of a liquid. The dyes are usually thickened with starch, dextrin, or gum arabic. If it is necessary to use a mordant, the mordant and the dye are used at the same time, or they may be applied separately. The present standard method of textile printing is by the intaglio method, or printing on rotary machines. The process is as follows:

The design is engraved on copper rollers. The designer makes sketches of the pattern, or if it is a large pattern, he determines upon the repeat of the pattern and separates the design, making a sketch on a zinc plate for each portion of the pattern for each roller. The zinc plates are then taken to the plate-cutter, who outlines the design so that it can be traced. The copper rollers

FIG. 60
DIRECT PRINT

are polished, covered with an acid-resistant paste, and placed in the machine. The pattern is then traced on the plate and the design is scratched through the paste and reproduced on the copper rollers.

The roller is next placed in an etching bath, where it rotates in the liquid until the design is of the required depth. The surplus paste is removed and the roller is ready for the print-

ing machine. The material to be printed is placed in the machine; the printing rollers, color pans, and finisher rollers are also placed in the machine, and the machine is adjusted. The

FIG. 61
DISCHARGE PRINT

next step is the setting of the color doctor, a steel blade which scrapes off all of the dye on the rolls, except in the engraving. This is followed by the setting of the lint doctor, a blade which removes all of the lint from the cloth. As the material is printed it is drawn back and forth and run over drying cylin-

ders to dry the color, the color being set by a steaming process. It is then cleaned to remove all foreign matter, starched, stretched, dried, and finished.

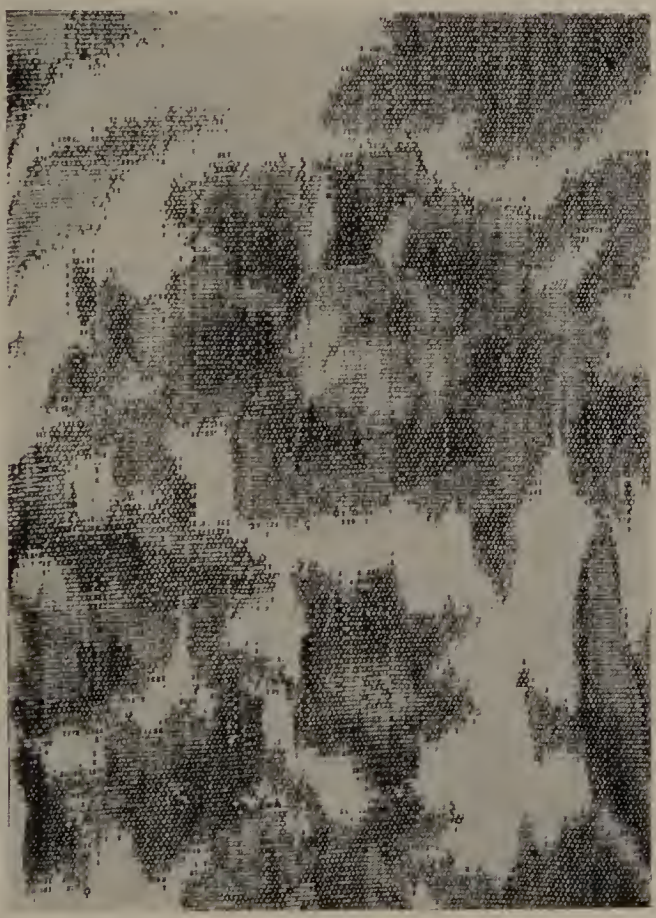


FIG. 62
WARP PRINT

Kinds of printing. There are several methods of printing fabrics with which the student should be familiar.

a. Direct printing. This is the most common method. The dyes are applied directly to the fabric, either alone or with a mordant.

b. Discharge printing is removing the dye with a chemical, which is applied to the dyed fabric and leaves the design either white or a different color from the ground.

c. Resist printing is producing white figures on a colored ground, by applying a substance which the dye stuff will not penetrate. When dry, the cloth is immersed in the liquid dye. The places covered with the resist paste are white when the paste is removed.

d. Topping is accomplished by reprinting a fabric after it has been printed once. The topping color is usually the darker.

e. Warp printing is printing a design on the warp threads on the loom before it is woven. This gives a soft indefinite effect.

Factors to be considered before dyeing fabrics. In order to be successful in dyeing textile fabrics, it is necessary to consider the following points:

1. The chemical composition of the dyestuff and of the fiber must be known, also the purpose for which the material is to be used. Different materials demand different methods of dyeing. The animal fibers have a greater affinity for, and take the dyes more readily, than the vegetable fibers.
2. The material must be thoroughly saturated with water before being immersed in the dye bath.
3. The container must be large enough for the material to be completely covered with the dye solution and not be crowded.
4. The material must be kept in motion in the dye bath throughout the whole process. This usually requires about one half-hour.
5. The material must be thoroughly rinsed after dyeing; that is, until the water runs clear.

CHAPTER XVIII

FINISHING FABRICS

Bleaching. Different kinds of materials require different methods of finishing. Practically all cloths have some particular finish. One of the first processes of finishing cotton and linen materials is *bleaching*. Bleaching is done in order to remove the wax, the gum, and the adhering oil, and to correct the decolorization of the material received in the manufacturing processes. The process is as follows:

1. Bolts of material about fifty yards in length, stamped with the manufacturer's name, are sent to the bleacheries.
2. The material is first singed to remove the protruding hairs.
3. It is then steeped and washed to loosen and remove the sizing.
4. It is placed in a weak solution of caustic soda and milk of lime and left there for from eight to ten hours. This removes all fats and wax from the cloth.
5. It is then washed thoroughly in water to remove the excess lime.
6. The material is at this point scoured by passing it through an acid bath of hydrochloric acid to counteract the action of the alkali.
7. It is then placed in another alkali bath and boiled in hot lye or resin soap for several hours. This changes the fatty acids to soluble soap.
8. It is then washed and transferred to the bleaching bath proper, which is called *chemick*. In this bath the material is treated with a cold solution of calcium hypochlorite for three or four hours.

9. The material is washed and passed through a solution of dilute hydrochloric, sulphuric, or acetic acid, a step which frees the chlorine from the bleaching solution. When the material is exposed to air and water, the oxygen is liberated. This free oxygen attacks and destroys the coloring matter. This process is called *white sour*.

10. The material is now washed in water, followed by a weak acid bath to stop the action of the chloride of lime, after which it is thoroughly washed again to remove the acid.

As linens contain more coloring matter than cotton materials do, the processes of chemicking and souring are often repeated several times with them.

Dressings. Dressings are often applied to cotton and linen materials to give more body and luster. They are usually applied in the form of a liquid paste on the back of the cloth, which is then passed over hot rollers. Starches, fats, glucose, and minerals are used. The starches, which include those made from wheat, potatoes, rice, and corn, give a luster and a finer finish. A more permanent dressing is made by treating with caustic soda at the freezing-point for an hour, thus forming a gum which is called *apparatine*. Glucose, which is used for weighting, is made by treating starch with an acid. Fats are used to give a soft, supple finish. The fats used are waxes, paraffin, different kinds of oils, and tallow. Minerals are also used to increase the weight. Minerals so used are acetate of lead, China clay, and alum.

Finishes. The finish of cloth has a great effect on the appearance, especially of cotton and linen materials. It may be produced in several different ways.

a. Calendering. This gives the material a luster, but it is not a permanent one. Calendering is done by passing the cloth between heavy rollers. As the fibers are flattened out, a glaze is produced on the surface of the cloth.

b. Beetling. The process of beetling gives linen the satin-like sheen and the cold, leathery feel which a good quality of the material should possess. This effect is produced by passing the cloth, after it has been dampened and wound on a roll, through a machine called a *beetle.* The cloth, as it is slowly turned, is hit with hammers; as a result, small places which reflect the light are left all over the surface of the cloth.

c. Moiré. This watered effect is another form of calendering. The cloth is run through calenders on which the moiré design is engraved, either on one roller or on both. This process presses some of the threads flat, leaving the others round.

d. Embossing. This process produces patterns in relief. The patterns are stamped on the cloth with engraved rollers.

e. Schreiner finish. This form of finish is still another means of calendering. The cloth is passed under pressure between rollers, which are covered with a great number of finely engraved lines. The round threads are pressed flat, so that the flat surfaces are broken up into planes. This finish reflects the light much better than an ordinary surface and gives a higher luster.

f. Satin finish. Sateens are treated with glycerine and then passed through the calender to give the satin finish. Cottons may also be given a silk-like luster by treating with Glauber's salt. If a rustle or scroop is desired, they are treated with common salt.

g. Mercerizing. This process consists of imparting a silk-like luster by the action of caustic soda under tension. This may be done either to the yarn or to the material.

In mercerizing the cotton yarns, the skeins of yarn are first boiled and then placed in the mercerizing machine, where they are treated with caustic soda under tension and washed under tension to remove the alkali. The skeins are then taken from the machine, washed again, and placed in a dilute bath of sul-

phuric acid to neutralize the alkali and to remove the sulphate of soda produced by the action of the caustic soda and the acid.

In the warp process, the yarn is made into long warps, which are run through a mercerizing machine, in which, by continuous treatment in different compartments, the yarn is boiled, saturated with a strong solution of caustic soda, washed, neutralized with sulphuric acid, and washed again. It is then ready for the finishing process.

Mercerizing cloth is a process similar to mercerizing yarn. The cloth is first boiled, then saturated with a caustic soda solution. This is usually done on a padded machine, where the liquid is forced through the fibers by squeeze rollers. As soon as the cloth has been thoroughly saturated, it is placed under tension, in such a way that both the warp and filling threads are kept under proper tension to avoid shrinkage in the length and the breadth of the material. The cloth is then washed under tension and placed in a dilute acid bath to neutralize the caustic soda. In the final operation, a softening compound is used to neutralize the acid and to soften the fibers, which have become harsh from the treatment with caustic alkali.

h. Lisle finish. This finish is obtained by rapidly passing the cotton yarns over gas flames, by which the projecting ends are singed off; in this way a smooth, glossy yarn is produced. It is then treated with a weak acid solution, dried, and run through an alkali bath.

i. Composition dots. These are made of white or colored paste and applied to the cloth with copper rollers like those used in printing, but an adhesive paste is used instead of the dye paste.

j. Waterproofing. This may be done in three different ways: (1) The fibers may be subjected to the action of superheated steam, making them water-repellent. (2) The fibers may be

charged with a substance which is water-repellent, therefore preventing the passage of the water. (3) One side of the fabric may be covered with india-rubber or a similar agent, making it waterproof.

k. Fireproofing. This is commonly used for cotton materials having a nap. The material is thoroughly impregnated in a sodium stannate solution. It is then squeezed to remove the excess, dried by passing over heated copper drums, passed through a solution of ammonium sulphate, squeezed, dried, and washed thoroughly.

Finishing of woolen materials. This process is performed as follows:

1. The materials are first perched or examined to detect all imperfections.
2. By the burling process, all knots are drawn to the surface of the cloth and clipped off. The loose ends are then cut off, examined for imperfections, marked, and sent to the mender, who darns and mends the imperfect places.
3. Three fulling processes are then used; the material is first scoured with hot water and soap to remove any oil or sizing. It is then scoured and rubbed between revolving rollers a second time for several hours in order to shrink the material.
4. The cloth is dried in a hydro-extractor, where most of the moisture is thrown off and the material is stretched the full length desired, and set. This is called *crabbing*.
5. By a process called *tentering* the fabric is straightened, after which it is passed through a trough to give the necessary amount of moisture, and is then brushed.
6. If the material is to have a nap, it is stretched tightly over revolving cylinders, which are covered with teazels or small wire hooks. These hooks or teazels scratch up the surface of the cloth, opening up the fibers, and thus forming the nap. This is called *napping*.
7. Usually the material is at this point given a luster by forcing steam through the cloth and then running it through cold water. The steaming brings out the luster and the cold water fixes it.

8. The final processes are stretching, shearing, brushing up the nap, polishing with sandpaper, pressing, inspecting, measuring, rolling, wrapping, and packing.

Finishing of worsted materials. The worsted materials do not go through as many processes as the woolen ones do. They are burled, singed, crabbed to set the weave, slightly fulled in some cases, scoured, rinsed, and sheared.

CHAPTER XIX

ADULTERATION OF FABRICS

There are several reasons for the adulteration of materials. Probably the most important reason is that women know so little about the manufacture and adulteration of cloth that they do not demand better-wearing fabrics. Then, too, people have more changes of clothing than they did in our grandmothers' time, and the styles change more frequently. Both men and women spend more on dress than formerly, and this usually means more money expended for quantity rather than quality of garment. For this reason the manufacturer puts out a greater variety of fabrics. As people demand cheap materials, the manufacturer, in order to supply the demand, must either combine different fibers or adulterate the materials. Usually the wearing qualities of the cheapest materials are questionable; it does not always follow, however, that the high-priced materials will wear well. For this reason it is to the advantage of the purchaser to know the approximate cost of the standard materials.

Methods of adulterating. There are a number of ways of adulterating materials.

a. A fabric may contain two kinds of fibers. For instance, wool and cotton may be sold for all-wool. There are two kinds of wool materials, woolens and worsteds; and the methods of adulterating are quite different. The woolen yarns are composed of the short wool fibers, loosely twisted and so carded that they lie in all directions. These yarns may have a cotton warp

and a wool filling, or they may have cotton and wool in both warp and filling. If the material is napped, the nap obliterates the weave and it is hard to detect the cotton. The worsted yarns are composed of the long wool fibers, which are so carded and combed that they lie in parallel order and are tightly twisted. These yarns may be adulterated by twisting the wool fibers around the cotton fibers in spinning, thereby concealing the cotton.

Mercerized cotton is often combined with linen or silk. This is particularly true of linen. High-priced linens have been found to contain a few fibers of flax, mixed with mercerized cotton in the warp; while the cheaper linens very frequently contain both mercerized cotton and linen in both warp and filling. Sometimes goods made entirely of mercerized cotton are sold for linen. These materials have usually been so well treated that the substitution can be detected only under a high-power microscope.

Before the World War, low-priced fabrics were manufactured and placed on the market which were called *unions,* and were part linen and part cotton. During the War, the flax industry was decidedly retarded. The flax fields of Belgium and the linen-mills in France and Belgium were destroyed. The mills in Ireland could not supply the demand. Consequently, in order to meet the demand, cotton was combined with the linen. During the War and for some time after, as a result, few all-linen materials were manufactured, and the price of all-linen fabrics was almost prohibitive. At the present time, though the prices are not so low as they were before the War, they are lower than they were during the War. It is now possible to purchase all-linen fabrics or materials of part linen and part cotton.

b. The weight of materials may be increased. Loosely woven materials, such as cheap muslins, cambrics, and linens,

are sometimes weighted by filling in the open spaces in the weave with starches or pastes. This process gives the appearance of a closely woven material. In order to detect this weighting, the material may be torn or washed. If the material is weighted, the starch will dissolve when it is washed, leaving a soft, sleazy material; when it is torn, a white powder will fly from the material. Organdies should have a permanent dressing, one that will not wash out. Cheap window-shades are often weighted by filling in. For this reason they crack, and after a short time wear through.

The weight of silk may be increased by the addition of certain metallic salts. Silk loses from 5 to 30 per cent of its weight in the boiling-off process. This amount of weighting may be added without noticeable injury to the fibers. It has been proved that silk will absorb as much as 140 per cent. This accounts for the splitting of taffetas after they have been worn only a few times. There are comparatively few taffetas which are not overweighted. Consequently their wearing qualities are rarely guaranteed. To test for the weighting in silks, a sample may be burned. If it is weighted, it will turn black, keep the shape of the sample, and have a metallic luster. If it is not weighted, it will turn black and curl up in a ball.

Wool is often weighted with magnesium chloride, which possesses great hygroscopic properties. When the wool cloth is passed through this weighting solution, the cloth absorbs the chloride, which remains in the cloth in a liquid form.

c. Materials may be given a deceptive finish. Mercerized cotton may be given the cold, leathery feel of linen by beetling, just as linen is beetled. Cheap organdies are starched to give the appearance of a permanent dressing. Dotted swiss is sometimes imitated by printing paste dots on a sheer cotton material. These dots will wash off when the material is laundered and turn brown when it is ironed.

d. Made-over yarns may be used alone or in combination with cotton or new wool. According to statistics, there is only about one-half enough new or virgin wool on the market to supply the demand. For this reason, reworked wool fibers, called *shoddy,* are used.

As the high cost of materials made from virgin wool alone places them above the price which the average consumer can pay, it is necessary to produce a fabric which looks well, is serviceable, and is comparatively cheap. This is often done by using well-selected reworked wool fibers, and blending them with virgin wool. This produces a good fabric of excellent wearing qualities, in many instances a better material than one made from a poor grade of virgin wool. Shoddy, however, is often blended with cotton or made from a poor grade of all-wool. This produces an inferior fabric.

Another form of shoddy, which is an adulteration, is flocking. The short fibers of wool which the clipping machines take from napped materials are often flocked, or felted between the warp and the filling threads of loosely woven materials. In order to detect these flocks, a few of the warp and the filling threads may be raveled over a white paper or cloth. If the material is flocked, these filling particles will drop out.

Shoddy is sometimes used in silk as well as in wool. It consists of recovered silk fibers from old silk materials. These fibers are usually very short, and stray fibers of wool and cotton as well as different colored fibers are sometimes present.

e. Processes of manufacture may decrease the wearing qualities of fabrics. There are a number of factors which determine the wearing qualities of materials. Of the utmost importance is the weave of the cloth. To a large extent, the durability of the fabric is determined by the kind of weave and by the methods used to produce the different kinds of weaves.

From the standpoint of durability, the plain, twill, and gauze weaves are considered the best.

Plain weave. The plain weave has a number of factors which may alter its wearing qualities. In a plain weave such as the basket weave, in which both warp and filling are composed of groups of many threads, there is a tendency to pull. Because the threads cannot be tightly woven, they ravel readily. Monk's cloth is a good example of this tendency.

A material may have two sets of alternating threads, one set having one size of yarn, and the other either a finer or a coarser yarn. In such a material, the finer threads break away from the coarser. This is also true of materials having an occasional heavy cord either in the warp or in the weft, or in both, for the purpose of forming stripes or checks. The finer threads of the plain weave between the cords break away from the cords.

In a material woven with a warp and filling of a wiry yarn, the yarns have a tendency to slip over each other. The warp and filling in rayon voiles often separate from each other, for example, on account of the texture of the yarn, which is slippery and wiry. Consequently holes appear in the fabric.

Novelty materials made of especially prepared yarns which are irregular in diameter are often loosely woven, as in ratine and the wool material called *friska*. Because they pull so easily, the threads usually pucker the material and often break, leaving holes in the material.

Materials are sometimes woven with a warp of tightly twisted yarns, while the filling may be only slightly twisted, if at all, or vice versa. The loose twist to the yarn is usually an indication of a weak yarn.

Sometimes the selvage formed in weaving is imperfect. It may be drawn too tight, which would cause the fulling of the material next to the selvage when it is laundered. In cheap towels, two towels are often woven together and then cut. One

side of the towel will have a selvage and the other side will be bound to prevent fraying, forming a fake selvage.

Twill weaves. While the twill weave is considered one of the strongest, it may have variations which are not so strong. The length of the floats in the satin weave varies. The shorter the float, the better the wearing qualities.

Swivel and lappet weaves. Dotted swiss which has a swivel weave does not wear as well as the swiss with a lappet weave. Because the dots are not fastened on the wrong side of the material as they are in the lappet weave, there is a tendency for them to pull out with repeated laundering.

Pile weaves. Pile fabrics vary in wearing qualities. In cut piles, such as velvets, velveteens, plushes, and velours, the length and density of the pile determine the durability to a large extent. In uncut piles, such as terry cloths, which are used principally in bath-towels, the thread count varies. The cheaper towels are usually one-pick; the medium priced, three-pick; and the better grades may have as high as six picks. Often the cheaper towels are so constructed that after the first laundering the loops pull out, leaving a plain, loosely woven towel.

Imperfections in weave. Imperfections in weave also play an important part in the wearing qualities of fabrics. Many of the materials found on the bargain-counter are seconds or slightly damaged goods. A few of the more common imperfections are: (1) oil spots; (2) soiled threads; (3) knots; (4) occasional places where the threads have been broken and other threads woven in with a needle; and (5) imperfect selvages caused by drawing the threads too tight or not tight enough. For this reason, the bargain-hunter should carefully examine all materials and garments before purchasing, in order to detect any imperfections.

Textile organizations. While up to the present time we do not have any legislation relating to "pure fabrics," much is

being done, in textile laboratories and by various organizations, which will tend to improve fabrics. An exhaustive study is being carried on constantly of ways of increasing the quality and quantity of raw fibers and of improving methods of manufacture.

a. The Silk Association of America. Among the organizations which have probably contributed most is the Silk Association of America, which seeks to increase the quantity and improve the quality of silk. Through suggestions and financial aid, this association has already accomplished a great deal in the Far East by promoting modern methods of sericulture.

New standards for silk-weighting have recently been formulated by a committee of the Silk Association for silk manufacturers and dyers. These will go into effect immediately. A number of manufacturers have already agreed to accept these standards, which include the following requirements: Weighting of silk shall not exceed 50 per cent for satins, 40 per cent for crêpe de Chine and Canton crêpes; 30 per cent for georgettes; 10 per cent for chiffons; and 30 per cent for the printed silks.

b. The Associated Knit Underwear Manufacturers of America are carrying on research, and have recently standardized measurements for knit underwear.

c. The Southern Textile Association. Through tests of standardization, production, and costs, the Southern Textile Association and its affiliated research organization, The Arkwright, Inc., are improving conditions.

d. The Laundryowner's National Association has given out valuable information to laundrymen and to the public regarding the results of the research work it maintains.

e. Textile institutes. Recently, institutes such as the Cotton Institute, the Wool Institute, and the Rayon Institutes have

been organized, primarily for the purpose of conducting research along economic lines.

f. Schools and colleges. The Mellon Institute, the textile schools, and a number of colleges and universities are contributing valuable information from research studies carried on in their laboratories.

g. The Bureau of Standards. Through the Bureau of Standards, with its skilled research workers, the United States government tests and reports on the various kinds of commodities which the purchasing agent of the government must buy. These various goods are tested in laboratories where the determining factor is quality rather than cost. During the past year, the Bureau has accomplished a great deal in the making of analyses used in drawing specifications for government buyers, and in standardizing some of the manufactured products. Manufacturers are using these standardized products as a measure for all other grades of each particular product.

CHAPTER XX

BUYING FABRICS

Standards of buying. There are certain standards to be observed by the buyer in the selection of materials for clothing or household use. It is estimated that about 96 per cent of the textile fabrics sold in this country are purchased by women. From an economical standpoint, therefore, it is quite essential that women realize the importance of intelligent shopping. The study of textiles is a means to an end, but it will not function in this way unless the individual can apply the knowledge gained to the intelligent selection and purchase of materials. The efficient shopper should:

a. Have a knowledge of the different kinds of materials; of the processes of manufacture, as they affect the wearing qualities; and of the methods of adulterating fabrics, in order to determine the probable wearing qualities of goods.

b. Have a knowledge of the factors which determine the cost of materials. These include the preparation of the raw material for manufacture; the transportation of the material from the source of supply to the factory; the manufacturing processes used; the making or manufacture of garments; and the cost of labor, the overhead expenses, and the upkeep of the manufacturing plant. Frequent changes of style in both fabrics and garments have a great influence on the cost.

c. Be able to discriminate between the essential and the non-essential, and to consider the different problems involved in economical buying. The standard materials are always in com-

petition with the seasonal novelties, and the conservative styles with the ultra-fashionable and the fad. The value of the ready-to-wear article should always be compared with that of goods bought by the yard and made up either at home or by a seamstress or dressmaker. In making this comparison, one should take into consideration such items as the quality of the material, the price of the ready-to-wear article in comparison with the price of the material bought by the yard; the cost of making; and the time consumed in going to the dressmaker. If the article would be made at home, the expenditure of time should be considered. Could that time be more profitably spent in some other way?

d. Consider the suitability of dress to the individual type and to the occasion of wearing. Dress should be appropriate to the wearer. The color of the gown, coat, or hat should harmonize with the color of the hair, eyes, and complexion of the individual. The appropriateness to the occasion is governed to a large extent by the social status of the individual.

e. Have a motive for buying. Some shoppers buy articles for which they have no immediate need, simply because they are cheap. It is usually more economical to buy only those things for which one has immediate use. This does not apply to staple notions, because a good manager should always have on hand a supply of hooks and eyes, snaps, buttons, bias tape, darning cotton, needles, and thread. Occasionally shoppers are over-persuaded by salespeople to buy articles which they do not really want. The shopper should remember that salespeople in large department stores often receive a commission on their sales; therefore, it is to their advantage, from a financial standpoint, to induce their customers to buy.

f. Know where to get the best value for the money. This is a most important question for one who has to economize. It may not always be expedient to patronize home merchants, if

better values can be obtained in near-by cities or by mail. From an economical standpoint, however, if one is shopping in near-by cities, the railroad fare and the additional expenses connected with the trip must be taken into consideration. In large cities, certain stores may carry some particular line which is better than that carried in other stores of the same city. Very often good values for less money can be bought from well-known and reliable mail-order department stores.

g. Take advantage of season sales. It is often advisable to take advantage of season sales. White goods sales usually take place in all large department stores in January and February. At this time underwear and white goods by the yard are much cheaper than at other times. Shoe sales usually take place in February and August. Bargain sales should, as a rule, be avoided. Reliable firms, however, often have special sales, when very good values are offered at reduced prices.

h. Give careful consideration to the problem of how to pay for articles bought. The advantages and disadvantages of charge accounts should be carefully weighed. One should avoid the temptation to buy non-essentials because they can be paid for next month. The habit of returning articles charged or of having articles sent on approval should not be formed. There may be some arguments for buying on the instalment plan, but "Never buy what you cannot pay for" is a good axiom to follow.

It is a good thing to be known by the marks of a thoughtful shopper. A successful shopper should be considerate of and courteous to the salespeople. She should not have them take down numerous articles or bolts of materials which she has no intention of buying. Possibly, also, she is keeping the salesperson from making other sales. She should shop early in the day if possible, before the stores are crowded. Late Christmas shopping should be discouraged.

Hygiene of clothing. In the careful selection of materials, the hygienic properties of the different fibers and fabrics should be studied. Proper clothing should contribute to the health of the individual. Clothing should aid in maintaining a constant body heat. The normal temperature of the body is 98.6 degrees. No matter what the climatic conditions, this temperature should be maintained.

Seasonable dress. A person should dress according to the season. In warm weather, light-colored, loosely woven and loosely constructed garments are preferable. In cold weather, several layers of thin clothing are more satisfactory than one layer of heavy clothing. A closely woven cloth is much warmer than one loosely woven, as it prevents the free passage of air to the body. Dress should be so constructed that it will permit freedom of action for every part of the body. Tight garments constrict the normal functions of the body. Tight collars retard circulation.

Clothing should be sanitary. The body gives off daily, through the sweat-glands, a secretion of water, and through the sebaceous glands of the skin, oils. These secretions are absorbed by the clothing. In order to prevent the glands from becoming clogged, the perspiration must be removed. If it stays on the garment, the open spaces in the cloth become clogged, which prevents ventilation. For this reason, the kind of fiber and the construction of the material are important factors. Garments should be made of materials that will stand frequent washing and boiling. Cotton and linen are more satisfactory, therefore, than wool or silk; and knitted materials, because of their porosity, are preferable to woven goods.

CHAPTER XXI

GOOD TASTE IN THE SELECTION OF TEXTILES

In previous chapters on fabrics, the different kinds of materials were discussed, together with their manufacture and wearing qualities. There are, however, other factors of equal importance in the selection of textiles for both clothing and household use.

Materials may also be judged by the same art principles applicable to a beautiful painting. Because of their beauty, some textiles have been preserved through the ages, and many of the originals and reproductions are found in our museums. Pictures of them have also been preserved in books and magazines. At the present time, these historic fabrics provide inspiration to artists, textile designers, and interior decorators; and the fundamental art principles found in them furnish the foundation for the beautiful in all textile design.

Of the utmost importance is the design of the material selected. Because there are so many materials in the shops to-day, one is quite bewildered when one tries to select those materials which are good in design and which will also give a lasting satisfaction, regardless of cost.

The three most important factors to be considered in the selection of fabrics are their usefulness, their suitability, and their beauty. To a great extent, the suitability of the material for the purpose for which it is to be used, and the general appearance of the material selected proclaim the taste of the buyer.

Good taste is the ability of the individual to select those things which are lovely and refined, and which will harmonize with her surroundings. The woman who dresses in good taste and selects beautiful furnishings for her home is an artist in the true sense of the word. While good taste is determined largely by the environment of the individual, it may be acquired by the study of art principles and the application of those principles to the selection and use of fabrics. Good taste is estimated to a great extent from the design, color, and texture of the fabrics selected, their suitability for the purpose for which they are to be used, and their unity. All these should produce an harmonious whole.

Design is either structural or decorative. Structural design is determined by the outline and the size of the object designed. It should be beautiful, simple, in good proportion throughout, and suitable for the purposes for which it is to be used.

Decorative design is the decoration of the surface of the structural design. It should emphasize the structural, should be subordinated to it, should be a consistent part of the whole, and always should be used in moderation.

All design is based on three elements and each is dependent on the others: (*a*) line, (*b*) dark and light, and (*c*) color.

a. Line. Line is the principal element of visual art. It may be expressed by a combination of lines, by the boundary of shapes, or by the relation of the lines to the spaces. According to the late Arthur W. Dow, in his book *Composition*, "Spacing is the very groundwork of design." Mr. Dow gave five ways of creating harmony in proportion to good spacing. They are (1) opposition, (2) transition, (3) subordination, (4) repetition, and (5) symmetry.

1. Opposition: This is shown in two opposing lines, for instance a horizontal line and a vertical line.

2. Transition: Often a third line, connecting two opposing lines, modifies or softens the result, forming a transition.

3. Subordination: Unity is created by arranging a dominant element so that all of the other parts are subordinate to it. This may be accomplished by means of variety in sizes and shapes, radiation, or grouping around a main axis.

4. Repetition: Repetition comes through repeating the same lines or spaces in rhythmical order. Rhythm or related movement may be gained through a repetition of lines or shapes, through a progression of sizes or a continuous line movement.

5. Symmetry: Lines or shapes in exact or formal balance bring symmetry. Both sides are alike. The opposing quality is asymmetry or informal balance, and is composed of unequal areas which, however, give a feeling of balance.

b. Dark and light. Dark and light depend upon the quality of the light reflected. In combining the different masses, beauty depends upon the arrangement of dark and light spaces and areas.

Because of the great variety of materials found in the shops to-day, many of which are poor in design and color, it is quite necessary for the consumer to have definite standards which will help her to choose those materials which will give complete satisfaction. Only by the application of the principles of design may these standards be attained.

Line should direct the attention to a point of interest. Lines are either straight or curved. Because of their severity, straight lines are strong and dignified, while curved lines give variety. The finest arrangement of line expresses unity and rhythm. If there is a variety of sizes and shapes with equal proportions of light and dark, the design is much more interesting than it would otherwise be.

There should be unity in the different parts of the design. All parts of the pattern should be harmonious in shape and

proportion. The design of the textile should be orderly in arrangement, should give the impression of rhythmic movement, and should avoid spots. For these reasons, the conventional design is better than the realistic.

c. Color. Color has a definite place in life and has a decided influence upon the individual. In order to understand its use, it is necessary to study color and to be able to analyze it.

Color has three dimensions, hue, value, and chroma or intensity.

Hue is the quality by which one color can be distinguished from another. Red, yellow, and blue are hues.

Value is the quality by which light is distinguished from dark.

Chroma is the intensity or strength of the color. According to the Munsell theory, there are five principal colors and five intermediate colors. The principal colors are red, yellow, green, blue, and purple. The five intermediate colors, found between the principal colors on the color-wheel, are red-yellow or orange, yellow-green, blue-green, blue-purple, and red-purple.

A combination of color which gives a pleasing effect is called a *color harmony.* Color harmonies may be divided into three main groups: self-toned or monochromatic harmonies, analogous harmonies, and complementary harmonies. A *self-toned or monochromatic harmony* consists of a hue with its tints or shades, or both. An *analogous harmony* is composed of the adjacent colors on the color-wheel, such as yellow and yellow-green, or red-purple, red, and red-yellow. The *complementary harmonies* combine those colors which are opposite on the color-wheel, such as yellow and blue-purple.

If the complementary colors are mixed, they give neutral or gray. The neutral colors are white, black, and gray. White is a combination of all colors; therefore it has the highest value. White reflects color and increases size: black, which is

the absence of color, absorbs light and decreases size; gray is produced by the mixture of the complementary colors or of white with black.

Color is a means of self-expression, and the selection and arrangement of colors reveal either a cultivated taste or poor judgment on the part of the user. If used in the correct place and in the right amount, color is beautiful. To a large extent, balance in color is governed by the law of areas. While the smaller areas may show strong accents of color, the larger areas should be so distributed that they will balance.

Color should show rhythmic graduations or an orderly arrangement. This can be accomplished by the repetition of the color or by holding colors together, the dark and light or the bright and dull being arranged with intermediate hues or values. Unity gives strength and subtlety. If rightly used, variety in color is much more interesting than monotony. By color-contrasts variety is obtained.

The color combinations brought out in the different types of color harmony may not always produce a pleasing combination of color. While the self-toned or monochromatic harmony is the simplest and safest, it becomes monotonous unless the contrast of intensities is strong. If two light values are separated by a dark one, or vice versa, the effect is often more pleasing.

In the analogous harmonies, the values of the adjacent colors may be so close that there is no contrast. There should be a contrast of intensities or values. By separating the colors with black or white, a more pleasing harmony may be produced.

The complementary harmonies, when used together, produce the greatest possible contrast. For this reason it is advisable not to use equal areas. More desirable is a large area of one with just a touch of its complement.

A neutral color may be accented by a note of either white or

a hue. The neutral colors give a dignified background for contrasts with hue in small areas.

Color harmony depends upon the principles of design; therefore, the violation of one principle will destroy the unity of the whole.

Texture. Texture also plays an important part in the selection of materials. Texture may be soft or stiff, thick or thin, heavy or light in weight, smooth or rough, or lustrous or dull.

Materials which have a smooth, lustrous surface reflect the light, do not blend in color so readily as rough, dull surfaces, and are more trying than soft, dull textures. While a rough texture casts shadows and gives a vibration of color, a dull surface absorbs the light. Two fabrics of the same color but of different texture often appear different in hue. Soft, pliable materials may be used in a variety of ways; on the other hand, the harsh, stiff fabrics are severe, and so not suited to many uses.

Design is also affected by the weave. Plain weaves have practically no limitations, while the elaborate figure weaves break up areas and limit the decorative possibilities of the design.

Having a knowledge of these art principles and an ability to apply them, women can select textiles and furnish their homes on an artistic basis. Only those women who are so equipped will choose those patterns and colors in wallpapers, rugs, and draperies that will give a lasting satisfaction, and will select the colors and styles of clothing which are becoming and suitable to their individual types.

CHAPTER XXII

TEXTILES USED IN CLOTHING THE FAMILY

As dress is an expression of personality, it is essential that the materials for clothing be carefully selected. A careful buyer should not only plan the family wardrobe according to individual requirements and the money available, but, in order that she may obtain the best values, she should also be able to judge the quality of the various materials and have a definite knowledge of the different kinds of materials and their uses.

Beside fulfilling certain esthetic requirements, dress should meet accepted standards of health and economy. The esthetic requirements which every one strives to fulfil differ according to the type and standards of the individual. The standards which should be considered are beauty in design, color, and texture, becomingness, style, suitability to the individual type, use, and simplicity. Simplicity is the key-note of good taste.

From a hygienic standpoint, only those materials should be selected which can easily be cleaned and laundered, and which will give the protection to the body needed to maintain normal temperature.

From the standpoint of economy, the clothing budget should be carefully planned, and the amount to be expended for the clothing of each individual should be worked out according to needs and income.

CLOTHING FOR WOMEN AND GIRLS

Fashions in materials, as well as in style, change frequently; therefore, the materials listed below include only the more or

less standard ones in vogue at the present time. The textiles used for women's garments are found in dresses, suits, coats, underwear, night-clothes, negligées, kimonos, bath-robes, and hosiery.

Dresses. There is an almost unlimited number of materials suitable for dresses which are required for all occasions.

a. House-dresses should be made of those cotton materials which are easily laundered, such as gingham, percale, broadcloth, and chambray.

b. Afternoon dresses. The materials used for afternoon dresses vary according to season, climate, the social status of the wearer, and the individual type of the wearer. For all-year wear, crêpe de Chine, Canton crêpe, flat crêpe, pussy-willow taffeta, and georgette, which is made either in plain colors or in prints, are suitable. More suitable for the sports type of dress are pongee, rajah, and the rougher textures. In warm climates, the light-weight cottons and linens are most satisfactory. A few of the standards are the more or less transparent materials—voiles, organdie, dotted swiss, and handkerchief linen. For winter wear in cold climates, the light-weight wools, such as serge, transparent tweed, georgette, and many of the new novelty wools, are satisfactory. Dress for the school-girl should be extremely simple in design and texture.

c. Formal evening wear. The materials are usually in bright colors, pastel colorings, black, or white. Chiffon and transparent velvets are especially good. Because the pile crushes readily, however, the wearing qualities of the latter are not so good. The all-silk chiffon velvets are much more durable. Chiffon, silk voile, georgette, and taffeta are considered very good, and the metallic cloths, spangled silks and satins, and laces are usually in vogue. With the exception of the metallic and spangled materials, all of the above are appropriate for informal

wear, the difference being in the style of making for different uses.

d. The tailored suit usually plays an important part in a woman's wardrobe. This may be of a rough texture, such as tweed, homespun, and the season novelties, or of a smoother surface, such as kasha, the various twills, and jersey. While not so tailored, the ensemble comes in a great variety of materials, often including the heavier silks.

Coats. Materials for coats are usually of two weights, those for spring and autumn, and those for winter wear. Materials used for the former are often the same as those used for the tailored suit. For the latter, however, heavier materials are more suitable, some of these materials having a heavy nap or a pile. Materials for coats also vary according to occasion.

a. Sports coats usually are made of tweeds, homespuns, Oxford cloth, or materials having stripes or plaids, and are made according to the prevailing style.

b. The more dressy coats. In these coats, the materials used are those which have a heavy nap, such as velour, carmenia, and broadcloth; those with a pile, such as bolivia and plush; and the fur fabrics, including the imitations of fur, caracul cloth, and beaver cloth, which are found in the cheaper coats. Fur coats have a wide range in price, according to the kind and quality of the fur.

c. Rain-coats are made of materials which have been waterproofed by a special process, as, for example, the cravenettes, tweeds, and those materials which are made of rubberized cloth.

d. Evening wraps are usually made of materials which are rich in texture. Examples of these are satin, velvet, and the more expensive furs, like sealskin, which are combined with contrasting fur for trimming.

Underwear. The kinds of underwear and the materials used have undergone a decided change in the past few years. Almost entirely, silk and rayon have replaced the cotton and wool used for underwear worn in former years. The amount of underwear worn at the present time has been reduced almost to the minimum, and may consist of vests, bloomers, or combinations, step-ins, brassières, and slips. The materials used for the vests, bloomers, combinations, and step-ins are crêpe de Chine, pussy-willow taffeta, flat crêpe, and knitted materials of either Italian silk or rayon. For sports wear, knit cotton underwear is often used.

The need of the individual should govern in selecting the type and weight of underwear. From a hygienic standpoint, knit underwear is most satisfactory for several reasons, some of which are as follows: (1) It is warmer, because of the air-spaces which act as an insulator against cold. (2) It is more elastic, the amount of elasticity varying according to the fineness of the yarn and the number of stitches to the inch. (3) It absorbs moisture more readily than a woven fabric, the amount depending upon the kind of fiber. (4) It is more porous, on account of the loop construction which provides a succession of air-spaces, giving the skin the needed ventilation.

a. Slips are made of cotton, silk, combinations of cotton and silk, and rayon. Most suitable among the cotton materials are sateen, lingette, soisette, rayola—the latter being a combination of cotton and silk—and radiux chiffon, a combination of cotton and rayon. There are a number of materials of all-rayon and all-silk, including radium, pussy-willow taffeta, flat crêpe, crêpe de Chine, Canton crêpe, and wash satin.

Night-clothes include night-gowns and pajama suits. The night-gowns are made of cotton, silk, and rayon, the cotton materials being fine cambric, Berkley #150, nainsook, and batiste. The pajama suits are made of broadcloth, English

prints, fine ginghams, and the like. For both gowns and pajama suits, the silk materials are crêpe de Chine, Canton crêpe, broadcloth, wash satin, and pongee. Materials of the various kinds of rayon are also used to a large extent.

Negligées, kimonos, and bath-robes. Negligées, which include lounging robes and breakfast coats, are often quite elaborate in design. They may be of lace, silk with lace trimming, or all silk. More simple in design than the negligées are the kimonos, appropriate materials for which are the cotton crêpes, silk prints, pongee, crêpe de Chine, radium, and pussy-willow taffeta. Most expensive and most beautiful of all are the Japanese kimonos of silk with elaborate embroidery. Much heavier and less attractive than either the negligée or the kimono are the bath-robes, which are made of blanket cloth, terry cloth, corduroy, eiderdown of either all-wool or wool and cotton, and the more expensive quilted silks.

Hosiery. Stockings usually come in either the circular knit or the full-fashioned style. Although the former has been greatly improved during the last few years, the latter has the better shape and is the more expensive. The best cotton hose are mercerized with a lisle finish; the cheaper ones are made of untreated cotton. Winter hose come in wool-and-silk and wool-and-rayon mixtures, and in all-wool. While the cheaper silk hose are often made of silk combined with rayon or of a very cheap quality of all-rayon, the better qualities are all-silk.

Men's and boys' wear. While style plays an important part in men's and boys' clothes, the cut and fit of the garments are of equal importance.

The principal factors to be considered in selecting the fabrics are serviceability and durability. Materials should be firm enough to stay in shape as well as to wear well. The fabrics most commonly used for suits are the firmly woven worsteds in either plain or novelty mixtures; the unfinished worsteds;

the softer woolens in plain or novelty mixtures; serge; mohair-and-wool or mohair-and-cotton mixtures; the Irish, Scotch, and Harris Island tweeds; gabardine; and cheviot. Men's suitings of the best quality are imported, for as yet the materials made in the United States for men's suits cannot compete in quality with those made in the British Isles.

Flannels, serge, unfinished worsteds, pongee, Palm Beach cloth, and mohair are the materials most used for summer wear. The better quality of mohair is the kid clip; another quality has a linen warp and a mohair filling; and the cheaper quality has a cotton warp with a mohair filling. In some of the Southern States, fine ginghams in stripes or checks, and seersucker suits are worn.

a. Dress-suits. For the full-dress suit, a worsted material, with a Barathea weave, specially made for this purpose, is used. As the name indicates, the tuxedo suits are made of tuxedo cloth, a material having a narrow self-tone stripe.

b. Overcoats. Varying according to the season and use, overcoats are made of rough or soft textures, such as tweeds, homespun, Oxford cloth, camel's hair and wool mixtures, llama and mohair mixtures, heavy woolens, and worsteds. For coat-linings, the better quality of coat-satin is used. The better grades of lining are all-silk, either Skinner's or Belding's, while the cheaper satin has a cotton back. Other materials used are sateen, rayon-and-cotton mixtures in either plain or twill weave, mohair, and alpaca.

c. Shirts. The materials which are the most satisfactory are madras, percale, English broadcloth, pongee, habutai, crêpe de Chine, silk broadcloth, and radium.

d. Underwear. The most satisfactory underwear for men's and boys' wear is the knit union-suit, which comes in cotton, rayon, cotton and wool, and all-wool. Union-suits and shirts and trunks, in both knit and woven materials, are cut in the

athletic style. Trunks are often made of materials with colored stripes.

e. Pajama suits and night-shirts. Pajama suits are made of English broadcloth, cotton crêpes, madras, outing flannel, silk broadcloth, crêpe de Chine, pongee, and Canton crêpe. Night-shirts come in cambrics, muslins, or other white materials.

f. Lounging robes and bath-robes. Lounging robes are made of blanket cloth, quilted silk, brocaded silks and rayons, and wool materials in dark colors. Blanket cloth and terry cloth are used for bath-robes.

g. Hose. Socks are either full-fashioned or circular knit, and come in cotton, mercerized cotton with a lisle finish, wool-and-silk, wool-and-rayon, wool-and-cotton, all-wool, or all-silk.

Clothing for the children. The health and happiness of the child depends to a great extent on the character of his clothing. Common sense, rather than style or fashion, should govern the mother in her selection.

Children should not be conscious of their clothing. As play is an important factor in the life of the child, the garments should be comfortable, simple in design, and made of those materials which can be easily laundered and cleaned. Because of the rapid growth of the child, his clothing should be inexpensive.

a. Outer garments. Outer garments should be suitable to the age, the coloring, and the figure of the child, and depend somewhat on the occasion for which they are worn. The materials should be serviceable, easily laundered, and fast in color. In the life of the child, color plays an important part, for, aside from its becomingness, color has a distinct effect on the child's disposition. The child should therefore be allowed to wear bright colors. There are many materials suitable for children's garments.

1. Dresses: These are made of French gingham, English prints, dimity, flaxon, voiles, and challie. If silks are worn at all, taffeta, pongee, and habutai are the most suitable.

2. Rompers and every-day dresses: The materials for these include gingham, Devonshire, kindergarten cloth, Indian head, Japanese crêpe, galatea, and chambray.

3. Coats: The material should be plain in color and the coat simply made. For winter, a closely woven fabric of plain color having a rough texture is best; for summer, taffeta, bengaline, and light-weight worsteds are desirable.

b. Underclothing. Much more satisfactory than the two-piece are the one-piece garments which hang from the shoulders. Elastic bands should not be worn, as they restrict circulation, breathing, and digestion. Clothing which is to be worn next to the skin should help to maintain a constant body temperature, should absorb perspiration, and should give proper ventilation to the skin. For this reason loosely knit underwear is more desirable than woven, and the union-suit is preferable to two garments.

1. Bloomers: As the bloomers take the place of the petticoat, they should be made either of the same material as the dress or of black sateen.

c. Sleeping garments. For winter, one-piece pajamas with feet attached are the best. These may be made of Canton flannel, outing flannel or muslin. For summer wear, the night-dress or night-shirt may be made of cambric, nainsook, or long-cloth; and the pajama suits, of checked gingham or striped English broadcloth.

Infants' clothes. In the character of infants' clothes there has been a radical change. The numerous, long, elaborate garments for infants made by our mothers and grandmothers have given place to a few simple, attractive garments which are used to-day by our modern mothers.

In selecting garments for a baby, the following should be kept in mind:

1. The materials should be soft, dainty, and easily laundered.
2. Not only the garments should be simple in design, but the trimmings and decorative stitches as well.
3. All garments should be loose enough to permit freedom of movement, as the infant uses most of its energy in growth.
4. Garments should be of such a character as to keep the body temperature at normal; therefore, the clothing should be suited to the season.
5. The cloth should be especially hygienic, as cleanliness is one of the essential factors in promoting the health of the child.
6. Garments should be so constructed that they can easily be put off and on.

The amount of money to be expended governs the number of garments in the layette, but the minimum is given below. The layette should consist of the following: six white cotton slips or dresses, six night-gowns or wrappers, three flannel petticoats, three nainsook petticoats, three knitted shirts, three knitted bands with shoulder-straps, three flannel binders, three dozen diapers, three pairs of long bootees or stockings, three pairs of woolen socks, one cap, one pair of thumb mittens, and two blankets.

a. Slips and dresses. These should be very simple in design, and made of very soft materials, in the butterfly or kimono style. Nainsook, batiste, and Berkley cambric ₵100 or ₵150 are the most suitable materials.

b. Night-gowns or wrappers. For the first few weeks, these garments are used every day and night; therefore they should be extremely simple. They should be made of flannel, flannelette, outing flannel, or cotton stockinet.

c. Petticoats. The petticoat should hang from the shoulders. For a new-born child, it should be made of a light-weight part-

wool flannel; later it may be made of nainsook, cambric #100, or long-cloth.

d. Shirts. Shirts are found in all-wool, wool-and-silk, wool-and-cotton, or all-cotton. For winter wear, they should be of at least half wool. The mixtures of either wool and cotton or wool and silk are considered better than the all-wool fabrics.

e. Flannel binders or abdominal bands. If these are used, they should be twenty-four inches long by seven inches wide. The material should be very soft.

f. Knitted bands. Those made of wool-and-silk, or wool-and-cotton are softer than the all-wool.

g. Diapers. The diapers must be soft and absorbent. The most satisfactory are those of cotton or linen birdseye, the latter being more desirable because it is more absorbent than cotton. Other materials used are Canton flannel, outing flannel, cotton stockinet, and the newer tubular-knit material manufactured especially for infants.

h. Baby bunting. Most satisfactory for winter wear is this garment, which is a three-in-one. The cap is attached to the coat. At the cuff of each sleeve there is a draw-string, and a flap buttons up over the feet. These are made of white flannel or cashmere lined with silk, and are sometimes knitted or crocheted of wool yarn.

CHAPTER XXIII

TEXTILES USED FOR HOUSEHOLD DECORATION

Not only on the kind of furniture bought does the artistic furnishing of a house depend, but also on the choice of fabric furnishings. These include floor-coverings and materials for shades, curtains, hangings, and upholstery.

There are four factors which the individual must consider in the selection of house furnishings: (1) family income; (2) environment; (3) social status; and (4) lasting satisfaction from an artistic standpoint and durability from an economic standpoint.

In order to furnish a home satisfactorily, it is necessary to devote a great deal of time to the selection of proper textiles in order to produce an harmonious whole.

Aside from the textiles to be used in furnishing, the use or function of the room, the lighting, the wall-paper, the woodwork, and the color-scheme of the adjoining room must be considered.

It is often more advantageous for a person who has to be economical to buy a few things at a time. These, however, should always be the best he can afford. A general plan for the whole should be worked out and kept in mind when buying. In this way, everything will harmonize. As with dress, the keynote of artistic furnishing is simplicity. A modest home which is simple and artistic and furnished within the income of the family will give a feeling of comfort and restfulness. On the other hand, one which is very ornate and cluttered creates a feeling of unrest and lacks real comfort.

Floor-coverings. As the floor-coverings are only a part of the furnishing of a room, all of the appointments, the wall-coverings, the hangings, and the upholstery of the furniture, should harmonize.

If the walls and hangings are plain in color, the floor-covering may be figured. Conspicuous figures, however, should be avoided; the conventional designs are considered the better. Plain or two-toned rugs are often desirable from a decorative standpoint, but are not considered practical because they show footprints. Of the rugs plain in color, taupe rugs show footprints least of all and usually blend with color harmonies.

In the choice of floor-coverings, rugs are usually preferred to carpets because they are more easily cleaned, and at the present time are more in vogue.

a. Oriental rugs. It is not always wise for a person in moderate circumstances to select Oriental rugs. In this connection, however, it should be remembered that there are as many different qualities of Oriental rugs—in texture, pattern, and color—as there are kinds of domestic rugs. In quality, the Oriental rug depends upon the number of stitches to the inch, the fineness and luster of the yarn, and the color and design. The Oriental rug is heavier than the domestic rug of the same size. The pile is put in in rows, with the knots all tied by hand. The best Oriental rugs are dyed with vegetable dyes, and are much more beautiful in color and more fast to light than those dyed with aniline dyes. When the pile is separated, the kind of dye may be detected. If the rug is dyed with vegetable dyes, the color will be deeper near the knot than on the surface. Rugs dyed with aniline dyes fade to a different color.

b. Domestic rugs. Of the domestic rugs, the Wiltons are considered the best in color and design, and give the best wear. There are several grades of Wilton rugs, The Anglo-Persian being the most expensive. These are similar in color and design

to the Persian rugs and are made of the best quality of worsted yarns. Another grade of Wilton rug is the French Wilton, which is of excellent quality, but not as good in color as the Anglo-Persian. Although the royal Wilton is less expensive than the Anglo-Persian or French, the nap is shorter. Of all the Wilton rugs, the Wilton velvets are the cheapest.

The Axminster rugs are cheaper than the Wiltons, but are not as good in color and design. In addition, they have a long pile which wears off and pulls out with wear.

The Brussels rugs, while not so rich in color and texture, wear well. They have a short, close, uncut pile which gives a harsh feel and a stiff appearance.

Window coverings. There are three kinds of window coverings, (*a*) shades, (*b*) curtains, and (*c*) hangings or overdraperies.

a. Shades. As they are a necessity, shades should be considered first. They are needed not only to keep out the sunlight, but also to serve as a screen from the passer-by.

The Holland shade, which is considered the best, is all-linen with a high glaze, and has excellent wearing qualities. Cotton shades come in all-white, colored, or duplex, which is white on one side and either tan or green on the other. If it is desirable to soften the light as much as possible, the duplex is very satisfactory.

In selecting shades, it is necessary to notice the weave. The material should be very closely woven. The shade may be held up to the light to see if the spaces between the threads are filled in with starch. If they are, it is advisable not to buy, because, after a short time, the shade will crack and split.

b. Curtains. Curtains soften the light and add to the furnishing of the room. They should be of some sheer material, usually all-white, cream-white, or écru. In selecting material for

curtains, one should consider the laundering and wearing qualities. The best-wearing curtain materials are casement cloth, plain nets, and marquisette. More expensive are the hand-made filet and tuscan nets, and much cheaper are the imitations. Marquisette, grenadine, curtain voile, and dotted swiss are more suitable for bedrooms. If a bedroom has a dominating color-scheme, small dots or figures in color on a white ground may be selected, but usually all-white, cream, or écru is more desirable. The color note may be introduced in the hangings or draperies. In parts of the country where there is a great deal of dust or soft-coal soot, a most satisfactory and comparatively cheap curtain material is theatrical gauze in the natural color This is made of flax, and therefore sheds dirt and dust more readily than a cotton material.

c. Hangings or over-draperies. To create an atmosphere by giving more color in the room, over-draperies are used. The color and texture of the hangings depend on the furniture, floor-coverings, and wall-coverings. If the walls and floor-coverings have a decided pattern, the hangings should be plain in color. Reed and fiber furniture demands cretonnes, linen, or cotton crash, or the more expensive hand-blocked linens or crewel embroidery on cotton. In a more formal room where the furniture is of mahogany or walnut, a fabric of richer texture would be required. Many of the rayon fabrics are very beautiful in color and texture, and quite expensive. Velveteen, silk, taffetas, and the new two-tone rayon taffeta are very good, especially if the rug is figured. A library or other room would require a heavier texture, if the furniture is rather heavy and massive. If a neutral or natural-colored material is desired, monk's cloth, craftsman cloth, hand-blocked linens, or crewel-embroidered cottons may be used. These may be lined either with plain, natural-colored crash or with sateen of a contrasting color. If a richer texture is desired, velours or velve-

teens may be used. The chintzes and cretonnes are particularly suitable for bedrooms.

Materials for upholstery. For wicker or fiber furniture, crashes, cretonnes, or cotton tapestries are used. The most suitable coverings for overstuffed furniture are tapestries, damask, rayon novelties, velours, and mohairs. The mohair wears exceptionally well, and is more fast to light than cotton velours. Patterns as well as plain colors may be obtained in these mohairs. For furniture having a framework of either mahogany or walnut, the damasks are more suitable. Often a color note is introduced in an odd chair, as for instance a wing-chair covered with glazed chintz.

CHAPTER XXIV

HOUSEHOLD LINENS

A half-century ago or more, household linens, which included table-cloths, napkins, sheets, pillow-cases, and towels, were made of all-linen. During the World War, very little linen cloth was manufactured and the price of linen was almost prohibitive; consequently, cotton bed-linen and towels and mercerized cotton damask were substituted. At the present time the term *household linens* does not necessarily mean that the articles are made of all-linen or even part linen.

Table linens. There has also been a decided change in the character of table linen during the past fifty years. Formerly table linen included only the damask table-cloths and napkins. To-day it also includes tea-cloths, luncheon sets, bridge sets, doilies, and silence cloths.

Table linens may be of all-linen, of part linen and part cotton, or of mercerized cotton. A good quality of linen is most desirable because of its beauty of texture, its whiteness, its resistance to soiling, its freedom from linting, its durability, and the ease with which spots may be removed from it. Mercerized cotton does not keep as white as the linen and does not stay clean as long, and spots are not as easily removed from it. The best quality of mercerized damask is the Basco, which is lintless. While mercerized cotton damask is much cheaper than linen damask, it is more desirable than a cheap quality of linen. Cheap linens are made from the short fibers of flax called *tow*. They are loosely woven, and heavily sized to give the appear-

ance of a firmly woven fabric. When the sizing washes out, a sleazy fabric is left which lints and is most unsatisfactory.

Linen damasks come in either single or double weight. Having more filling threads to the inch than the single quality, double damask is the heavier of the two. Double damask is reversible, showing the pattern as distinctly on one side as on the other. A good quality of damask should have a cool, leathery feel.

Most of the linen damasks come from Scotland, Belgium, Ireland, and France. Those from Scotland and Belgium are the cheapest. The Irish damasks have excellent wearing qualities, due to their croft or grass bleach. While the wearing qualities of French damasks are not as good as those of the Irish damasks, they are more beautiful in design as well as more expensive.

a. Table-cloths and napkins. Table-cloths may be bought by the yard or the pattern cloth. The latter has a border on all four sides. Among the standard sizes are these: two yards square; two by two and one-half yards; two by three yards; two by three and one-half yards; and two by four yards.

Napkins, which are sold in sets of either six or twelve, should match the cloth. The standard sizes are: luncheon and bridge napkins, from thirteen to sixteen inches square; tea and luncheon napkins, from eighteen to twenty-one inches square; breakfast and dinner napkins, twenty-two inches square. For the formal dinner, however, the twenty-four inch napkin is still used.

Most of the pattern table linen at the present time has either a plain satin border or a border in a conventional design. To match the border, many table-cloths have a decorative center panel. Some people prefer the perfectly plain satin damask by the yard. There is a wide range in prices: single damask by the yard ranges from $1.50 to $3.50 per yard, and double damask

ranges from $2.50 to $5.00 per yard. With the possible exception of the plain satin damask, however, the better quality of damask is found in the pattern cloths. The prices of the pattern cloths range from about $3.50 to $35.00, while the napkins average from about $7.00 to $15.00 per dozen.

Just at present there is a vogue for colored damasks, with either a white ground having a design in color, or a colored ground surrounded with white bands. These come in all-linen, or part linen and part rayon.

Very elaborate luncheon cloths and table-cloths, which have napkins to match, and which are suitable only for formal luncheon and dinners, are made of lace combined with elaborate hand embroidery on heavy linens. Among the most common patterns are mosaic drawn-work, Venetian and Spanish embroidery and Italian hemstitching. The most expensive are of all-over lace, in point de Venice, rose point, and point de France. A vogue of the moment is for luncheon and dinner cloths of heavy silk in exquisite colorings.

b. Luncheon and bridge sets. Luncheon cloths vary in size, the standard being fifty-three inches square, with the napkins from thirteen to twenty inches square. For bridge sets, a cloth one yard square with napkins to match is used, the sizes of the latter ranging from thirteen to twenty inches square. These sets come in linen with Italian, Spanish, or Chinese embroidery, or in plain hemstitched linen. The Czechoslovakian sets are of very fine damask in ivory white or colors with wide white borders. Cheaper sets which are very serviceable come in ivory white with colored borders. Inexpensive, easily laundered, and quite attractive are the blue and white Japanese crêpe sets, which are most serviceable.

Luncheon sets consisting of runners, eighteen inches wide by thirty-six inches or more long, with six oblong doilies twelve inches wide by eighteen inches long, and one-half dozen napkins

to match, thirteen inches square, are used for formal luncheons. For ordinary use these may be of all-linen with simple Italian drawn-work. The more elaborate sets are made up of ivory white linen in Spanish or Italian embroidery with lace insets or all-over lace of point de Venice or rose point.

Table pads. The table pad or silence cloth, as it is often called, is used to protect the table from hot dishes and to serve as a silence cloth. Of these, there are four kinds in common use: (1) a quilted cotton pad, (2) a cloth of double-faced Canton flannel, (3) felt, and (4) an asbestos mat. Because it is more easily handled, the last mentioned is bought in sections. All of the others may be purchased by the yard or cloth.

Towels. To give the best service, towels should be moisture-absorbing, durable, and easily laundered. Toweling may be purchased by the yard, or the finished towels may be bought separately or by the dozen. Towels may be divided into two groups: those for the bathroom, and those for the kitchen. In the former group are included hand-towels or face-towels and bath-towels, and in the latter group, the crash towels and glass-towels.

a. Hand-towels. Materials for the hand-towels are either of mercerized cotton or of linen. Because it absorbs moisture more readily than cotton and is easy to launder, the latter is much more satisfactory. A good quality of linen wears longer and does not lint so badly as cotton. For hand-towels or face-towels, huckabuck and damask are used. Damask is more expensive than huck, but is softer and more beautiful. The towels come with plain, hemstitched, or scalloped ends. The sizes vary from the guest size, which is 15 x 22, to the larger sizes, 18 x 32, 20 x 36, and 22 x 36. The prices range from about $7.50 to $15.00 a dozen.

b. Bath-towels. Because of its absorptive power and its rough surface, Turkish toweling or terry cloth, as it is some-

times called, is most desirable for bath-towels. The quality depends upon the weight, the thickness, and the fineness with which the loops are woven. In the cheaper towels the loops pull out and slip. The towels come in all-white, white with colored borders and vice versa, or with attractive Jacquard designs and monograms in color. The sizes are as follows: 22 x 44, 27 x 48, and 25 x 51. The prices range from about $6.00 to $12.00 a dozen.

c. Kitchen towels. Kitchen towels are either crash towels or glass-towels, of either linen or cotton, usually half-bleached. Often the crash toweling has colored borders on the sides, while the glass toweling comes in blue checks and red checks. Cotton glass-toweling is not very satisfactory, because it does not absorb moisture so readily as linen, and it lints more. Because of this fact, it is very undesirable for drying glassware. Material for towels can be purchased by the yard, or in the finished towel at about $4.25 a dozen, the size being 18 x 36 inches.

Wash-cloths. The most satisfactory material for wash-cloths is Turkish toweling or terry cloth, because of its rough surface.

Bed-linen. Bed-linen includes sheets, pillow-cases, bed-spreads, and mattress pads.

a. Sheets. In buying sheets, consideration of the size is of the utmost importance. If the sheeting is bought by the yard, the following points should be considered:

1. The length should be determined by the length of the bed.
2. The top hem should be three inches wide and the bottom hem one inch wide.
3. There should be an allowance of five inches for shrinkage on each sheet.
4. The sheets should be long enough so that the lower sheet can be tucked under the mattress about six inches at each end and the top sheet folded back over the other covers about eighteen inches. The best length is ninety-eight inches finished.

Other factors which should be considered in selecting materials for sheets are durability, fineness and firmness of texture, smoothness, and ease in laundering.

Sheets come in a variety of qualities. The poorest are the sized muslins and the unbleached muslins. The wearing qualities of the latter are very good, but the color is objectionable. Of sheetings there is an infinite number of brands. White English broadcloth is being used to some extent at the present time. Percale sheeting is considered the next best to linen. Because it does not wrinkle so easily, is whiter than muslin, and does not lint so much, many people who formerly used linen prefer percale.

Sheets are sold by the "torn length," meaning the length before hemming. They come in the single or twin-bed size and the double-bed size. Sheets also come in color, with pillow-cases to match, or in white with colored hems. For the single or twin bed, the standard sizes are 54 x 90, 54 x 99, 63 x 90, 63 x 99, 72 x 99, and 72 x 108. The double bed requires 81 x 99, 81 x 108, 90 x 99, or 90 x 108. The prices range approximately from $0.83 to $6.25 each for white cotton, and for the linen, from $7.25 to $18.75 each.

b. Pillow-cases. Pillow-cases are bought single, in pairs, or by the yard in the flat piece or in tubing. The materials are the same as those used for the sheets. They are listed according to the whole width or one-half the width. The sizes of pillow-cases are given in the torn length. The regulation size is 22½ x 36 or 45 x 36. For cotton, the prices range from $0.38 to $1.50 each, while linen ranges from $1.75 to $3.75.

c. Bedspreads. White, colors, or a combination of both may be obtained in bedspreads to be purchased or to be made. The materials are as follows: crinkled white dimity, either with hems or with scallops; fancy Jacquard-striped cotton with scalloped edges; rayon-and-cotton in solid colors or brocade;

cotton, hand-tufted in white or colors; and the more elaborate taffeta.

d. Mattress pads. These pads are used to protect the mattress. They are made of quilted, half-bleached muslin and come in sizes for the single or twin bed and the double bed.

Blankets and comforts. In addition to bed-linen, blankets and comforts are a necessary part of a well-stocked linen closet.

Blankets come either in the single size or in uncut pairs. They may be all-cotton, part cotton and part wool, or all-wool; and they come in white with colored borders, in plaids, and in solid colors. Sateen or satin is used to bind blankets at each end, while the more expensive single blankets are bound all around with either sateen or satin. The sizes are 60 x 80; 70 x 80; and 72 x 84. Prices are about $2.00 a pair for the cotton and from $7.50 to $27.50 for the all-wool.

Comforts are filled with cotton or wool wadding, or down, and are covered with cotton challie, silkaline, sateen, silk and cotton mull, cotton-and-rayon mixtures, figured silks, or satins. Because of their wide variety, the comforts come in several qualities, the quality being determined by the kinds of filling and covering. The better qualities are filled with cotton or wool wadding, or down, and are covered with satin or sateen. On the other hand, the cheaper qualities are filled with cotton or wool wastes and covered with the cheaper cotton materials.

CHAPTER XXV

FURS

While furs are not classified as textiles, they are so closely connected with textiles that it does not seem out of place to include a chapter on the subject in a book on textiles.

Several varieties of hair which have been removed from the skins of fur-bearing animals are used in the manufacture of textile fabrics. Fur, however, is used in the natural state; that is, the soft, downy hair is left attached to the skin of the animal, which is so treated that it can be made into most attractive garments. Most of the fur-bearing animals have two growths of hair: the soft under-hair, and the stiffer top-hair or guard-hair.

Fur is the best non-conductor of heat; therefore it is especially adapted for outer garments in cold climates. Garments made of the better kinds of fur are usually more costly than most of the fabrics used for clothing. In recent years, furs have become so fashionable that the demand in the United States far exceeds the supply.

Securing the fur. At the present time, fur-bearing animals are trapped either by farmers or by professional trappers, or the animals are confined on farms or the open ranges. The latter method is becoming more and more popular both in the United States and in the foreign countries.

a. Fur marketing. The trapper or farmer sells the skins of the animals to an itinerant buyer, to a receiving house, to a sales-house or auction-house, or direct to the manufacturer.

b. Itinerant buyers. In the United States, the itinerant buyer goes from farm to farm examining and appraising the skins, and finally, after much bickering, pays cash for the furs, which he bundles up and carries away.

c. The receiving house. The receiving house is generally located in some market town where there are good banking facilities and large warehouses. Here the skins are opened and examined by an expert, who makes a report to the office concerning the different kinds of fur, and the number, size, and relative quality in each shipment.

d. Auction sales. Fur sales or auctions are promoted through sales corporations in large cities, the furs being sold to dealers and manufacturers.

e. Fur markets. The most important fur-centers in the United States are St. Paul, Minneapolis, New York, Boston, St. Louis, Detroit, and Chicago; the chief foreign centers are Montreal, Canada, London, Paris, and Leipzig.

Treating the fur. The object of dressing fur is to arrest the decomposition of the skin in order to make it permanent and to destroy the odor. First, the skins are softened by soaking in a brine-soaked sawdust for twenty-four hours, after which the flesh is removed from the skin with knives. The skins are next partially dried, and made more pliable by soaking in a vegetable oil or butter. They are then pulled and stretched and placed in large revolving drums where they are tumbled about and rolled in sawdust in order to absorb the excess grease, after which they are dried either in a centrifugal extractor, or in especially constructed drying rooms.

a. Processes preceding the dyeing of furs. Before the furs are dyed, some of the skins, seal for instance, must be unhaired. This is done by removing the long guard-hairs, leaving the soft under-fur. Inferior skins of kids and lambs are often sheared to give the moiré effect. All furs must be "killed" before dye-

ing. This is done by dissolving the fatty substance in an alkali solution, which coats the fiber and prevents the fiber from absorbing the dye. The furs are then rinsed, neutralized, rinsed again, and mordanted.

b. Fur dyeing. Fur dyeing differs from fabric dyeing in that the regular dye bath is not used, but chemicals, which are applied by expert chemists. The dyes may be of mineral or vegetable origin, or they may be coal-tar products known as *ursols.* These are applied at a temperature of about 40 degrees centigrade. After this process the furs are washed, dried, drummed, and oiled as in the dressing process.

Kinds of fur. Most of the furs are taken from the pelts of wild animals; a few, however, are taken from domestic animals, the latter including the lamb, kid, and pony.

a. The marten group. The costliest pelts used for the most beautiful wraps, scarfs, and trimmings are found in the marten group, which include the various species of sable, marten, and mink. They are brown in color, ranging from deep yellow-browns to those which are almost black.

1. Russian sable: The Russian sable which is found in Siberia is the finest in texture and color, and the most expensive of all furs. It may be distinguished from the other furs by its thick, soft under-fur which is a rich brown in color, and by the long, lustrous guard-hair, which is longer than the hairs of the under-fur. Both of these hairs stand erect.

2. Hudson Bay sable: The Hudson Bay sable, often called the *American marten,* is a close rival to the Russian sable. The color, however, is more of a red-brown, and the fur lacks the luster of the Russian sable.

3. Baum marten: This fur, too, is similar to the sable, but not quite so dark in color nor so lustrous.

4. Stone marten: The stone marten is lighter in color and can be distinguished from the other martens by its white

throat. The fur shades from a stone-color on the sides to a dark brown stripe in the center of the back. The under-fur is a light brown.

5. Skunk: The skunk or polecat, often called *black marten,* is considered one of the best and most durable of the long-haired, black furs. It has two white stripes the whole length of the back, these being cut out before the fur is made up.

6. Mink: Classed also with the martens are the mink furs, though the skins are much smaller than the marten skins. The under-fur is soft, while the guard-hairs are stiff and lustrous. The color ranges from a light brown on the sides to a dark-brown stripe through the center of the back. The better skins are a rich brown, while the poorer skins are more of a yellow-brown.

7. Japanese mink and Chinese weasel: These furs are frequently used as substitutes for mink. The top-fur of both animals is much coarser than that of the mink, and there is very little under-fur.

8. Fitch: The fitch, or European polecat, has a very light-colored under-fur, while the top-fur is dark and glossy.

Civet-cat: The civet-cat or lesser skunk is brownish gray in color. It is very popular for sport coats.

b. The other furs of most importance, taken from wild fur-bearing animals, are the seal, beaver, fox, raccoon, opossum, squirrel, coney, marmot, and leopard.

1. Seal: Of the several species of seals, the Alaskan seals are considered the better by far, and all of these are owned and protected by the government of the United States. They have a short, close, soft fur, which is dyed brown or black and is exceedingly lustrous.

2. Beaver: The beaver, which furnishes one of the finest and most valuable of furs, is found in limited numbers in the northwestern part of the United States. The long top-hairs are

pulled out, leaving the shorter under-hairs. The color is a dark tan.

3. Fox: The fox is found in almost every country and in a large number of species. The silver fox is the most valuable. Other species, in order of quality, are the Alaskan blue or white fox; the cross fox, which has a dark cross on its shoulder; the red fox; and the gray fox, which is the cheapest. The pointed fox is a specially prepared fur. The red or white fox-skin is dyed black, and white hairs are inserted. The end of the white hair is dipped into a preparation of cement and inserted at various places to give the effect desired.

4. Raccoon: This is one of the most popular furs. It somewhat resembles the beaver. Its color is black, brown, or gray.

5. Opossum: Australian opossum is one of the most staple furs. The under-hairs are a bluish gray, while the woolly top-hairs are darker. American opossum has a rather coarse, thick hair which is often dyed to imitate the more expensive furs.

6. Squirrel: The bluish-gray squirrel from Siberia is considered the best, though the red and gray American squirrels are used to a large extent, being cheaper. The wearing qualities of the American furs, however, are not so good as those of the Siberian squirrel.

7. Coney: The coney is a species of rabbit, found in New Zealand, Australia, France, and the United States, the better qualities coming from France and being sold under the trade-name "near seal." Those found in the United States are inferior in quality.

8. Marmot: The marmot, woodchuck, or ground-hog produces an inferior fur ranging in color from gray to a dark brown. It is usually dyed to imitate mink.

9. Leopard: The leopard, which is found in Africa and Asia, produces the finest of the spotted furs. The smaller the spots, the better the quality.

10. Pony: The pony skins which come from Siberia are considered the most beautiful in texture. The skins are flat, and have a high luster and beautiful moiré markings. In color they range from light tans to a dark brown, while some are black.

11. Lambskins: There are several kinds of lambskins, the better-known being the Persian, broadtail, and caracul. Persian lamb is the skin of the Bokharan lamb, one of the most durable furs. The fur is fine, with a dark color and a close curl. The broadtail has a beautiful moiré effect. The fur is taken from the stillborn or unborn lamb. The better quality of caracul comes from Russia. The cheaper skins come from China, Mongolia, and Manchuria.

Matching the skins. Before the furs are ready to be made into garments, the skins must be matched. The points to be considered in matching skins are: quality, size, color, and length of fiber. The skins are then ready for manufacture.

CHAPTER XXVI

THE CARE OF TEXTILES

Textile fabrics cannot give the fullest and best service unless they are properly cared for, and they need constant care. A few general directions for the care of clothing and house furnishings may be considered.

Washing of wool goods. In order to clean wool materials without danger of shrinking them, they should be washed in warm water, not hot, with a mild soap, or with soap-chips. The soap should be free from an excessive amount of alkali and should not be rubbed on the material. The soap-chips should first be dissolved in hot water. The material should be soaked, before washing, in a warm soap-and-water solution for about one half-hour. It should then be placed in a clean suds solution and squeezed, not rubbed, until it is clean.

Soft water should be used if possible. If the water is hard, borax will soften it. In order to remove all dirt and soap, woolens should be thoroughly rinsed in warm water and through as many waters as necessary, at approximately the same temperature. The woolens should be squeezed, not wrung. The garments should be placed on a flat surface and pulled into shape before hanging. Wool garments should not be hung out in a freezing temperature.

Washing of rayon knit underwear. The following report is based on tests for the washing of rayon knit underwear which were prepared under the auspices of the Associated Knit Underwear Manufacturers of America.

a. Washing. Only a good quality of soap should be used and preferably in powdered or chip form (not soap-powder). Dissolve the soap in hot water (soft water is best). Wash the garments in warm water, at a temperature not exceeding 140 degrees Fahrenheit. If a washing-machine is used, there should be a sufficient amount of water to cover the garments, and a thick cushion of suds. Do not overload the machine. If washing by hand, do not rub the garments, but lift them up and down in the bath until the soap permeates the whole fabric. It is better to wear rubber gloves for this purpose, as rayon is a delicate fabric and is weaker in strength when wet than when dry. Be careful not to stretch or pull the fabric while it is wet.

b. Rinsing. Rinse for five or six minutes. Use water of approximately the same temperature as that used for washing, in order to avoid sharp contrasts in temperature. Handle the garments gently, and wear rubber gloves.

c. Drying. Do not use the roll-type wringer for getting rid of the excess water. The centrifugal type is more satisfactory. If no wringer is available, squeeze out the excess of water gently by hand. Do not twist the garments. Finish drying by laying the garment on a flat surface, and dry at the ordinary room temperature, 70 degrees to 80 degrees Fahrenheit. Do not hang the garments on a line or on the backs of chairs. Use a medium hot iron for pressing the garments.

Care of garments. Garments should be kept free from dust by frequent brushings. Dust often contains a great number of germs, which, if left in the garment, attach themselves to the fabric, where they multiply rapidly and make large spots, often injuring the cloth.

Garments which have been worn should not be put away until they have been thoroughly aired. Clothes-closets should be aired frequently.

Removal of stains. Stains should be removed before laundering if possible, for washing usually sets them. The following are a few directions for removing the more common stains.

1. *Blood.* Wash the stain in water with a small amount of ammonia.

2. *Coffee and fresh fruits.* Place the stained portion of the cloth over a bowl and pour boiling water on it from a height.

3. *Grease.* Wash in warm water and soap.

4. *Ink.* Moisten the spot with salt and lemon-juice and lay on the grass in strong sunlight. If the material is white, an ink-eradicator may be used according to the directions on the bottle, after which the spot should be thoroughly washed in a strong soap-solution and rinsed. Purple ink may be removed, even from colored materials, by covering the spot with common salt and saturating the salt with alcohol.

5. *Iron rust.* Dissolve in a bowl one teaspoonful of borax in one quart of water. Spread the stained portion of the cloth over the bowl and touch the spot with hydrochloric acid, drop by drop, until the stain becomes brighter. Dip in water and repeat until the stain disappears. Lemon-juice and salt may remove the stain.

6. *Machine oil.* Rub the stain with turpentine and wash in soap and water.

7. *Mildew.* When the stain is fresh, wash in cold water. If it is an old stain, apply javel water and wash in hot water.

8. *Tar.* Rub the stained portion with lard, then wash in warm water and soap.

9. *Water spots.* Hold the garment over steam until moist, then shake until dry.

Special care of wardrobe. Washable garments should be laundered frequently. Wool dresses and skirts should be sponged and pressed. Garments which cannot be laundered should be dry-cleaned occasionally.

Garments should be examined frequently and repaired when necessary. Stockings and underwear should be mended after laundering.

Dresses and coats should be hung away on hangers, and skirts on skirt-hangers. The sleeves of dresses and coats will keep their shape much better if they are stuffed with tissue-paper.

Light often fades the color of garments; therefore colored garments should be protected with covers made for that purpose. Such garments should be kept in a dark closet which can be frequently aired.

Garments should never be put away in a damp condition. Often if they are put away when damp, or in a moist atmosphere, they will mildew. This is caused by large quantities of microscopic plants, which penetrate the fibers of the cloth, causing a change of color in the cloth and often making it fall to pieces. This may be prevented by brushing the garment each time after wearing, and hanging or storing it away in a dry place, in a perfectly dry condition.

Protecting textiles against destructive insects. All textiles are subject to attack by insects, and certain fabrics have their particular species of enemy. The larvæ of case-making moths feed upon wool fabrics, carpets, furs, and feathers. This moth is distinguished by the grayish color of its head and fore-wings. The back wings are white or grayish and very silky. This variety is very common in the North. The larvæ of the webbing, or Southern clothes-moth, feed upon wool fabrics, hair, feathers, and furs. This moth has two broods annually: the first in June, and the second in September. The following are a few simple ways of preventing attack by the clothes-moth.

1. *Airing.* Garments should be frequently aired, thoroughly brushed, and beaten in the sunlight. They should be examined and aired at least once a month during the summer.

2. *Repellents.* Such repellents as tobacco, cedar chips, camphor, and moth-balls may be used. These repellents, however, will not have any effect upon the eggs or larvæ in the garments.

3. *Packing.* Wool garments, or furs, may be placed in boxes lined with heavy tarred paper. New paper should be used every year. Newspapers are very satisfactory, as the moth seems to dislike the printer's ink. Cedar chips are good as long as the odor of the cedar lasts.

4. *Cleaning of carpets.* Carpets should be thoroughly cleaned, and sprayed with benzene.

5. *Spraying of furniture.* Cloth-covered furniture should be sprayed with gasoline in April, June, and August. Care should be taken in using the gasoline, however, to avoid danger from fire.

6. *Storing of furs.* Furs should be thoroughly brushed, exposed to the sunlight, and then wrapped in newspapers or placed in boxes lined and covered with tarred paper. The best method of protecting expensive furs is to put them in cold storage. Here they are first exposed to a temperature of 40 degrees Fahrenheit, which renders the larvæ or other stages of the moths dormant. A low temperature will not destroy them, but by alternating a low temperature with a comparatively high one, the larvæ and insects are killed.

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PART IV

THE CHEMICAL ANALYSIS OF TEXTILES

THE CHEMICAL ANALYSIS OF TEXTILES

While there is a broad field in the study of textile chemistry for textile specialists and those interested in textile manufacture, textile chemistry is also of value to students of home economics in colleges. Such students should have a general knowledge of some of the simpler chemical tests. A course in textile analysis should include qualitative analysis, in order that students may detect the adulterations of fabrics; the fiber content of both the warp and filling yarns in materials; the weighting of materials; and the different kinds of dressings. It should also include a few quantitative tests to determine the amount of the different fibers, dressings, and weightings found in fabrics.

The Analytical Classification of Textile Fibers

Textile fibers may be classified from an analytical standpoint as follows:

1. The animal fibers which contain sulphur—wool, and the minor hair fibers—are known as the keratinic fibers.
2. The animal fibers which do not contain sulphur include the cultivated and wild silks.
3. The vegetable fibers which respond to the woody reactions are the *lignocelluloses,* these being jute, hemp, and the other minor bast fibers.
4. The vegetable fibers which do not respond to the woody reactions are the true celluloses, these being cotton, flax, and ramie, after they have been freed from their impurities.
5. The luster celluloses include the different kinds of rayons.

Some Simple Chemical Tests

The following are a number of comparatively simple chemical tests which can be carried out in an average chemical

laboratory, with ordinary equipment, by students who have had one year of chemistry.

I

DRY REACTIONS

(To recognize the composition of fibers)

Experiment 1. Place samples of wool materials in a dry test-tube and heat over a Bunsen burner. While the fumes are being given off, test for ammonia by holding a piece of red litmus-paper in the mouth of the tube. If ammonia is present, the litmus-paper will turn blue. Test for sulphur by holding a piece of filter-paper saturated with lead acetate solution in the mouth of the test-tube. If sulphur is present, the paper will turn brown or black. The odor is that of burning horn or any other epidermal tissue. The residue is carbon. Wool materials smolder and burn slowly.

Experiment 2. Repeat Experiment 1, using samples of silk materials. The results are as follows: red litmus turns blue on account of the vapors of ammonia given off. There is no sulphur present. The odor is not quite so disagreeable as that of wool. The residue of pure silk is in the form of a globule or ball. If weighted, the silk will keep the shape of the sample. Silk, like wool, smolders and burns slowly.

Experiment 3. Repeat Experiment 1, using samples of the different kinds of rayons. The results for viscose, nitrocellulose, and the cuprate silks are as follows: blue litmus turns red because of the acid present. There is no sulphur present. The odor is that of burning wood and the residue a white ash. These rayons burn with a flash. The acetate silk turns blue litmus red because of the acid present. There is no sulphur; the residue is black, and the odor very disagreeable. The acetate silks burn with a sputtering noise.

Experiment 4. Repeat Experiment 1, using samples of cotton and linen. The results are the same for both. Blue litmus turns red, showing the presence of an acid (impure acetic). There is no sulphur present. The residue is a white ash and the odor is that of burning wood. Both cotton and linen burn with a flash.

II

THE ALKALI REACTIONS

(To show the effect of strong alkalies on the different fibers)

Experiment 1. Place samples in a test-tube and cover with a 10 per cent solution of sodium hydroxide, and then boil. The results are as follows: wool is destroyed quickly; silk, less quickly; and the cotton and linen fibers swell.

Experiment 2. Place samples in a test-tube and cover with a cold 10 per cent solution of ammonium hydroxide. Results: the wool and the silk fibers are weakened considerably; the cotton and the linen fibers are not affected.

Experiment 3. Place samples in a test-tube and cover with a 10 per cent solution of sodium carbonate, and then boil. Results: the wool and silk fibers are slightly weakened; the cotton and linen are not affected.

III

THE ACID REACTIONS

(To show the effect of concentrated acids on the different fibers)

Experiment 1. Place samples of materials of the different fibers in a cold concentrated solution of sulphuric acid and note the results: silk is destroyed at once; wool is slowly destroyed as the solution dries on the fibers; linen dissolves slowly; and cotton dissolves very slowly.

Experiment 2. Place the samples in a cold concentrated solution of nitric acid and note results: silk is destroyed at once; wool, slowly; and cotton and linen, very slowly.

Experiment 3. Place the samples in a cold concentrated solution of hydrochloric acid and note results: silk dissolves, but not so quickly as in the other acids; wool is hardly affected; and the cotton dissolves more quickly than the linen.

Experiment 4. Place the samples in a cold concentrated solution

of acetic acid and note results: all fibers are not affected so much as they are in the other acids.

IV

DIFFERENTIATION TESTS

(To identify fibers in materials which are made of more than one kind of fiber)

The following experiments, given by different textile authorities, are for the most part color-tests. It will therefore be necessary to use white or light-colored materials only. In order to get the best results, the samples should be fringed on two adjacent sides so that both warp and filling threads are exposed.

A. Wool-and-Cotton

Experiment 1. Moisten the sample of wool-and-cotton mixture with Millon's reagent, and heat it. The wool fibers turn red, but the cotton is not colored.

Experiment 2. Immerse a sample of wool-and-cotton mixture in a 50 per cent solution of nitric acid. Wool fibers turn yellow, but the cotton does not color.

Experiment 3. Place a sample of the mixed material in a cold solution of picric acid and rinse in clear water. The wool turns yellow; the cotton is not colored.

Experiment 4. Place a sample in a fuchsin solution (decolorized); then wash and place in water acidified with acetic acid. Wool turns a magenta color; cotton is not colored.

Experiment 5. Heat a fringed sample in cochineal tincture in a water-bath. Remove and rinse in a strong solution of sodium chloride. Wool turns scarlet, but cotton turns a light red.

B. Silk-and-Wool

Experiment 1. Silk will dissolve quickly in a 40 per cent solution of hydrochloric acid; wool will dissolve very slowly.

Experiment 2. Heat a fringed sample of silk-and-wool mixture in a 5 per cent solution of sodium hydroxide, to which has been added enough lead acetate to form a heavy white precipitate. The wool will turn brown or black; the silk will remain uncolored.

C. Cultivated Silk and Wild Silk

Experiment. Place samples of both cultivated and wild silk in a 10 per cent solution of sodium hydroxide, and boil. The cultivated silk dissolves in about ten minutes; the wild silk will not dissolve in an hour or more.

D. The Rayons

Experiment 1. Immerse samples of the different kinds of rayons in a concentrated solution of sulphuric acid. Nitrocellulose or chardonnet shows no coloration for nearly an hour, then turns a pale yellow. Cuprammonium turns yellow at once, and viscose turns a reddish brown at once. The acetate silks become a very light brown, which deepens to a dark brown.

Experiment 2.[1] Heat samples of the different kinds of rayons in a test-tube containing 2 c.c. of Fehling's solution, in a water-bath for ten minutes; then fill the test-tube with water. Chardonnet or nitrocellulose turns green; cuprammonium and viscose turn blue. The acetate silks turn a reddish brown, which changes to a blue.

Experiment 3. Treat samples of the different kinds of rayons with equal parts of concentrated sulphuric acid and iodine. Viscose turns a dark blue; the acetate silks turn yellow; chardonnet or nitrocellulose turns violet; cuprammonium becomes a light blue.

Experiment 4. Immerse samples of the different kinds of rayons in a 50 per cent solution of acetic acid. The acetate silks dissolve at once; the other rayons are not affected.

E. Cotton and Linen

Experiment 1. Free samples of linen-and-cotton mixture from all dressings by boiling in a solution of sodium carbonate until all the dressing has been removed; then immerse them in concentrated sulphuric acid. Wash and dry between filter-papers. Cotton dissolves at once; linen is only slightly affected.

[1] From Griffin's *Technical Methods of Analysis,* p. 380.

Experiment 2. Place a fringed sample of linen-and-cotton mixture in a warm solution of methylene blue, and rinse thoroughly. The linen turns blue, but most of the color washes out of the cotton.

Experiment 3. Heat a fringed sample for five minutes in an alcoholic solution of rosolic acid, in a water-bath. Wash and place in a 10 per cent solution of sodium hydroxide. Rinse thoroughly. Linen turns rose-red; cotton remains uncolored.

Experiment 4. Immerse a fringed sample in a 1 per cent solution of fuchsin in alcohol. Wash and place in ammonia, then in a 10 per cent solution of sodium hydroxide. Linen turns rose-red; cotton becomes only slightly colored.

F. Mercerized and Untreated Cotton

Experiment. Boil samples of both mercerized and untreated cotton in several changes of water for two hours, then rinse thoroughly and place in a solution of iodine in potassium iodide and wash. Mercerized cotton turns dark blue or black; untreated cotton turns brown

V

QUANTITATIVE ANALYSIS

The following method is given by several different textile authorities:

Experiment 1. Wool-and-cotton: Weigh an air-dry sample of the material, then boil for twenty minutes in a 5 per cent solution of caustic potash, keeping it at constant strength by replacing the water lost by evaporation. The wool dissolves, leaving the cotton. Remove the cotton residue, rinse thoroughly, restore to the air-dry condition, and weigh. Cotton loses from 3 to 5 per cent of its weight through the action of the alkali. Therefore 3 per cent of the weight of the cotton is added to correct the loss. This is subtracted from the weight of the wool and expressed in percentage.

Experiment 2. Wool-and-silk: Weigh an air-dry sample and place in a 40 per cent solution of hydrochloric acid and steep for two minutes at a temperature of 120 degrees Fahrenheit. Silk dissolves, leaving the wool. Wash the residue, dry thoroughly, and weigh. The correction is 5 per cent.

Example:	*Grams*
Weight of air-dry sample	2.550
Weight of cotton residue	1.630
Difference (approximately wool)	.920
Correction (3% of 1.630 g.)	.048
Weight of cotton, 1.630 + .048	1.678
Weight of wool, .920 — .048	.872
Per cent of cotton	.66
Per cent of wool	.34

VI

TESTS TO DETERMINE THE DIFFERENT KINDS OF DRESSINGS [2]

Place a sample of the material in 200 c.c. of water and boil for several hours in order to dissolve all soluble matter, then test the solution as follows:

1. Starch: Add a few drops of iodine in potassium iodide to a small portion of the above solution. If starch is present, the solution will turn blue.

2. Dextrin: To a small portion of the extract, which has been concentrated by boiling, add when cool three times its volume of alcohol. If dextrin is present, it will be precipitated.

3. Gelatin: To a portion of the solution, add a small amount of tannic acid solution. If gelatin is present, there will be a gelatinous precipitate formed.

4. Sugar: Boil a portion of the extract with dilute hydrochloric acid, and add a few drops of Fehling's solution. If sugar is present, a red precipitate of cuprous oxide will be formed.

[2] Method suggested by Matthews in *Application of Dyestuffs to Textiles, Paper, Leather, and Other Materials*, p. 692.

5. Zinc: Add a few drops of ammonium sulphide to a small portion of the extract. If zinc is present, there will be a white precipitate of zinc sulphide formed.

6. Calcium: Add ammonium oxalate solution to a small portion of the extract. If calcium is present, there will be a white precipitate of calcium oxalate.

VII

THE DYEING OF TEXTILE FIBERS

(To show the action of different dyes on the different fibers)

Use one skein each of wool, silk, rayon, cotton, mercerized cotton, and linen. Take one gram of dyestuff to 1,000 c.c. of water.

Experiment 1. The action of acid dyes: Wet one skein of each and place in a boiling dye solution, keeping at the boiling-point for one half-hour. Wash thoroughly, examine, and note the difference in color of the different skeins.

Experiment 2. The action of basic dyes: Use malachite green, methyl violet, or methylene blue. Place two skeins of each, after thoroughly saturating with water, in the boiling dye solution, keeping in motion one half-hour. Wash one set of skeins thoroughly in water.

Experiment 3. Take one skein of each from the above solution and steep for one half-hour. Wash and compare with the skeins from Experiment 2. Note: Dissolve one part of tannic acid in six parts of water.

Experiment 4. Action of substantive dyes: Wet one skein of each and place in the boiling dye solution, using any direct dye. Keep in motion for one half-hour. Examine, and note difference. Note: A small amount of sodium chloride added to the dye solution deepens the dye on the fibers.

Experiment 5. Action of mordant dyes: Boil the skeins for twenty minutes in a bath containing 10 c.c. of chrome solution. Rinse and place with another set of untreated skeins, in a bath of

300 c.c. of water and 10 c.c. of alizarin red solution, and boil for one half-hour. Compare the results with the two skeins.

Experiment 6. Place a set of skeins for ten minutes in a cold solution of 200 c.c. of water and 5 grains of ferric chloride. Squeeze, and place in a cold solution of 200 c.c. of water and 2 grains of soda ash. This gives a deposit of iron oxide on the fibers. Dye with alizarin red.

VIII

TESTS FOR FASTNESS OF DYE

Experiment 1. Test for fastness to light: Place five samples of colored wash material under glass, one half exposed, the other half covered. Expose to strong sunlight and remove as follows: one sample each, at the end of one week, ten days, two weeks, three weeks, and four weeks. Compare and classify as to degree of fastness, as fast, fairly fast, and not fast.

Experiment 2. Test for fastness to washing: Baste a piece of white material to a piece of colored material, having one set of each for the following soaps: Ivory, Crystal White, Procter & Gamble's White Naphtha, and Fels-Naphtha. Wash a set of samples in each of the soap-solutions, using 5 g. of soap to 1 liter of water, at a temperature of 140 degrees Fahrenheit. Squeeze, rinse, and dry. Note if the solution or the white material is tinted. Classify as follows: Fast, *i.e.,* does not tint the solution or the white material; fairly fast, *i.e.,* tints the white material; not fast, *i.e.,* tints both the solution and the material.

Experiment 3. Fastness to perspiration: Steep the dyed material for five-minute periods for several hours, in a solution of 500 c.c. of water, 150 c.c. of acetic acid and 75 c.c. of sodium chloride. Note the change, and classify as fast, fairly fast, or not fast.

IX

REAGENTS USED FOR TESTING TEXTILES

1. *Fuchsin solution (decolorized)*: Dissolve 1 g. of fuchsin crystals in 100 c.c. of water; add caustic soda drop by drop, until the fuchsin solution is decolorized. Filter.

2. *Millon's reagent:* Dissolve 10 g. of mercury in 25 c.c. of nitric acid diluted with 25 c.c. water at a lukewarm temperature. Mix this solution with 10 g. of mercury in 20 c.c. of fuming nitric acid.

3. *Caustic potash or soda:* Dissolve 10 g. of caustic sticks in 100 c.c. of water, and filter.

4. *Lead Acetate:* Dissolve 5 g. of lead acetate crystals in 100 c.c. of water, and filter.

5. *Picric acid:* Dissolve .5 g. of picric acid in 100 c.c. of water, and then filter.

6. *Cochineal tincture:* Dissolve 1 g. of ground cochineal insects in 50 c.c. of alcohol, and then filter.

7. *Rosolic acid:* Dissolve 1 g. of commercial rosolic acid in 10 c.c. alcohol and add water to make 100 c.c.

8. *Iodine in potassium iodide:* Dissolve 3 g. of potassium iodide in 60 c.c. of water and add 1 g. of iodine. Dilute with 10 parts of water.

X

TEST CARD

For recording the results of tests of textiles, the outline shown on page 215 is recommended for students. The samples of materials to be tested should be mounted on cards.

Some of the characteristics to be recorded on the test card may be determined as follows:

1. *Fiber content:* The fiber content of both warp and filling is detected by microscopic and chemical analysis.

2. *Thread counts:* The one thread count is determined by the number of warp threads or ends, and picks or filling threads, per inch. The threads are counted with a thread-counter or pick glass as described on page 87.

3. *Twist:* The direction of the twist and the number of twists per inch is determined on a machine especially made for that purpose.

4. *Tensile strength:* The tensile strength is taken on a tensile strength testing machine which records the breaking-point in pounds on a dial.

5. *Dressing.* The sample should be weighed and boiled, and the aqueous solution should be tested as described on page 111. To determine the amount of dressing, the sample taken from the solution should be rinsed, dried, and weighed the second time, and the difference in weight recorded.

6. *Fastness to light and washing:* See the tests given on page 213.

RESULTS OF TESTS ON.....

Price per yard:

Width:

Weave:

Fiber content:
- Warp
- Filling

Thread counts:
- Ends
- Picks

Twist:
- Warp: Number per inch
  Direction
- Filling: Number per inch
  Direction

Tensile strength:
- Warp
- Filling

Dressing:
- Kind
- Amount

Fastness to light:

Fastness to washing:

General characteristics:

General quality:

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A FABRICS GLOSSARY

WOOL FABRICS

Albatross. A material 44 inches wide, of plain weave, loosely woven, and crêped.

Bedford cord. A rather heavy material, 45 inches wide, having heavy ribs in the warp direction.

Broadcloth. A heavy, fulled material 54 inches wide, of twill weave, with a nap which is pressed down to give luster.

Cashmere. A soft, light-weight material, 42 inches wide, with a twill weave.

Challie. A soft, light-weight material of plain weave.

Charmeen. A material 54 inches wide, of satin weave, finer and softer than most worsted materials.

Cravenette. A material 54 inches wide, of twill weave, having a mottled appearance, this effect being produced by twisting together tan and white or black and white yarns. It is often made waterproof.

Crêpe, Egyptian. A fabric similar to albatross, but heavier.

Crepella. A rather thin worsted material, 54 inches wide, of plain weave, crêped, often called *wool crêpe.*

Flannel, baby. A thin, white material, from 27 to 30 inches in width, of plain weave, having a slight nap. It may be of all-wool, wool and cotton mixed, or a silk warp with a wool filling.

Flannel, French. A heavier material than baby flannel, of twill weave, 54 inches wide, having a slight nap.

Flannel, viyella. A soft, thin material, varying in width from 30 to 46 inches, of twill weave, with a slight nap. It has cotton and wool in both warp and filling and is non-shrinkable.

Georgette. A fine, thin, transparent, crêped material, 54 inches in width, of plain weave. It resembles silk georgette.

Jersey cloth. A soft, thin material, 54 inches wide, plain knit.

Joseena. A soft, heavy coating material, 54 inches wide, of twill weave.

Kasha. A soft, thin material, 54 inches wide, of twill weave. It may be in the natural color or dyed. The best quality has long protruding hairs on the face.

Poplin. A material from 42 to 54 inches in width, having a slight rib in the weft direction.

Poiret twill. A material 54 inches wide, with a rib twill, smoother and softer than serge.

Shepherd's check. A soft, thin fabric, having small even checks in either white and black or white and a dark color. It is 54 inches in width and of twill weave.

Sicilian cloth. A thin, wiry material with a silk-like luster, 54 inches in width, of plain weave, with a cotton warp and a mohair filling.

Tricotine. A material from 46 to 56 inches in width, having a double twill, which looks as if it might have been knit.

SILK FABRICS

Broadcloth. A material 36 inches wide, of plain weave, having the filling threads heavier than the warp. It comes in plain colors and stripes.

Baronette satin. A heavy, stiff material, 40 inches wide, of satin weave, having a high metallic luster. It usually has a mercerized cotton warp and a rayon filling.

Bengaline. A heavy material, 40 inches wide, having a heavy rib in the weft direction.

Cameole. A rather heavy material, 40 inches wide, of satin weave, having a rayon warp and a silk filling. It is reversible, with one color on one side and a contrasting color on the other.

Chiffon crêpe. A very thin, transparent material, 40 inches wide, of plain weave, crêped.

Crêpe-back satin. A material 40 inches wide, of satin weave. One side is lustrous, the other dull. It is therefore reversible.

Crêpe de Chine. A soft, thin material, 40 inches wide, of plain weave, crêped. The best qualities are washable. It comes in plain colors and prints.

Crêpe romaine. A material heavier than georgette, of basket weave, and 40 inches in width.

Duvetyn. A heavy, napped fabric, from 38 to 40 inches in width, of satin weave. The warp is usually mercerized cotton, and the filling, silk.

Faille. A soft material, having a rib in the weft direction. The width varies from 38 to 40 inches.

Foulard. A soft, thin material, from 36 to 40 inches in width, of twill weave. It has a printed design of either direct or discharge printing.

Georgette. A thin, transparent fabric, 40 inches wide, of plain weave. It has a harsh feel, caused by the tightly twisted threads which give the crêpe effect.

Habutai. A soft, thin, dull silk, 36 inches wide, of plain weave. It is usually made of wild silk.

Moiré. A material 40 inches wide, having a slight rib in the weft direction and a watered effect.

Pongee. A material of wild silk in the natural color. It may also be procured in various colors. It is wiry, the threads are irregular, and it lacks the luster of cultivated silk. It varies in width from 27 to 33 inches and is of plain weave.

Satin, dress. A soft, lustrous fabric of satin weave, varying in width from 36 to 40 inches.

Satin pancross. A rather heavy, soft material, which is reversible. One side has an inconspicuous printed design, the other is satin in plain color.

Surah. A material 40 inches wide, of twill weave, having a harsh feel. It usually comes in checks or stripes.

Taffeta. A dull, stiff silk, of plain weave, with a rustle or scroop. It is often weighted.

Taffeta, grosgrain. Similar to the plain taffetas, with a rib in the weft direction. Often it is two-toned.

Taffeta, pussy-willow. A much softer material than the other taffetas, and lacks the rustle of taffeta.

Velvet. A material varying in width from 18 to 40 inches, of pile weave. It has a closely woven, cut pile of medium length. It is very soft and rich in texture.

Velvet, chiffon. A very soft, rich fabric, 40 inches in width, of pile weave. The pile is put in rows across the material and pressed down to give luster.

Velvet, panne. A very soft, thin, pile fabric, 40 inches wide. It has a longer pile and is more lustrous than chiffon velvet.

Velvet, transparent. A very thin pile fabric, 40 inches wide. The pile is of rayon or silk; the silk pile wears best and does not crush so readily as the rayon.

COTTON FABRICS

ABC silk. A thin, lustrous material, 36 inches wide, of plain weave, having a cotton warp and a spun-silk filling.

Batiste. A soft, sheer, translucent material, from 38 to 44 inches in width, of plain weave, often mercerized.

Cambric. A smooth white material, 36 inches wide, of plain weave. It comes in different qualities, according to the yarn count, as numbers 60, 100, and 150. The higher the count, the finer the material.

Canton flannel. A heavy, soft material, from 27 to 30 inches in width, of twill weave, and with a long nap on the face.

Chambray. A closely woven material, 32 inches wide, of plain weave, having a colored warp and a white filling.

Chintz. A material 36 inches wide, of plain weave, used for hangings. It usually has small, dainty patterns on a light-colored ground. The glazed chintz is similar in pattern, but is stiff and has a high luster.

Corduroy. A pile fabric, from 31 to 40 inches wide. The pile is so cut as to form ribs in the warp direction.

Cretonne. A material heavier than chintz, usually having large all-over patterns in rather brilliant colors. The warp prints are more indefinite in pattern than either the chintzes or the cretonnes.

Damask. A rather stiff material, from 64 to 72 inches in width, having a figure weave on a satin ground. It is usually mercerized and lacks the cool, leathery feel of linen damask.

Devonshire. A material 36 inches wide, heavier than gingham, with the filling threads heavier than the warp.

Dimity. A sheer fabric, from 30 to 32 inches in width, with occasional ribs in warp direction, forming stripes, or with ribs in both directions, forming checks or crossbars.

Dotted swiss. A sheer, stiff material, 36 inches wide, of lappet weave. A plain ground with the dots embroidered in. The cheap swisses often are of swivel weave, having a group of threads pulled through the cloth to form the dots. Some dotted swiss materials have composition dots.

English broadcloth. A soft material, 36 inches wide, of plain weave. The filling threads are heavier than the warp, and the material is usually mercerized.

Flaxon. A fine, sheer material, in plain weave, from 32 to 40 inches in width.

Gingham. A material from 27 to 32 inches in width, in plain weave, and varying in fineness according to the quality. It comes in plain colors, stripes, checks, and plaids.

Indian head. A heavy material, from 36 to 40 inches wide, of plain weave. It comes in white and colors.

Japanese crêpe. A thin, loosely woven material, 36 inches wide, of plain weave. It is crêped by twisting the filling threads tighter than the warp threads.

Lingette. A soft, lustrous material, 36 inches wide, of satin weave with a self-toned stripe. It is thinner than sateen.

Long-cloth. A soft, dull, white material, 36 inches wide, of plain weave. Not so heavy as muslin.

Madras. A soft material, 36 inches wide, of plain weave, having an occasional rib in the warp direction.

Marquisette. A very soft, thin material, 36 inches wide, of gauze weave, which forms an open, square mesh.

Muslin. A closely woven material, 36 inches wide, of plain weave. Closely woven and rather heavy.

Nainsook. A very soft, sheer material, of plain weave, from 36 to 45 inches in width.

Organdie. A stiff, sheer material, of plain weave, from 36 to 45 inches wide. The best qualities have a permanent dressing.

Outing flannel. A very soft material, from 27 to 36 inches in width, of plain weave. It comes in plain colors, stripes, and checks. It has a slight nap on both sides.

Percale sheeting. A material much finer and smoother than muslin, 45 to 72 inches in width. Most satisfactory for bed-linen.

Piqué. A heavy material 27 to 36 inches in width, having a heavy rib in the warp direction.

Plisse. A thin, soft material 32 inches wide, of plain weave and crêped by chemical shrinkage.

Radiux chiffon. A wiry, lustrous material, 32 inches wide, of plain weave. The warp is cotton and the filling rayon.

Sateen. A smooth-faced, lustrous material, of sateen weave, from 27 to 36 inches in width.

Terry cloth. A loosely woven fabric of uncut pile, 36 inches wide, with a design printed on both sides.

Ticking. A heavy, stiff material, of either plain twill or herring-bone twill weave or a combination of both. It is 32 inches wide, and usually has blue and white stripes.

Ticking, art. A softer material than the plain ticking, of satin weave, having a printed design, usually in stripes.

Velveteen. A heavy material from 27 to 36 inches in width, having a close cut pile. Not so rich as velvet.

Voile. A thin, loosely woven fabric, from 36 to 40 inches in width, of plain weave. The threads are very tightly twisted. The tighter the twist, the better the quality of the voile.

LINEN FABRICS

Art linen. A closely woven, firm fabric, from 36 to 72 inches in width; the best qualities have round threads, rather than flat threads.

Crash. A coarse material, from 16 to 36 inches in width, with irregular threads and usually in the natural color or half-bleached.

Damask. A lustrous material, 72 inches wide, having a figure weave on a satin ground. The best qualities have a cool, leathery feel.

Dress linen, Belgian. Softer and not so coarse or so lustrous as the Irish dress linen. It is 40 inches in width.

Dress linen, Irish. A soft, rather coarse lustrous material, 36 inches wide, of plain weave. It wrinkles readily.

Glass-toweling. A stiff, lustrous material, from 16 to 18 inches in width, of plain weave, usually having either blue or red checks.

Handkerchief linen. A sheer material, 36 inches wide, of plain weave, with fine irregular threads.

Holland. A stiff, lustrous material, from 27 to 36 inches in width, used for window-shades. It is usually sized with oil and starch to make it opaque.

Huckabuck. A soft material, from 18 to 27 inches in width. The weave is composed of tiny oblongs which are peculiar to huckabuck.

Theatrical gauze. A stiff, loosely woven fabric, of plain weave, used for window curtains.

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